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PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL
AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Mawatari — *Bryozoa from the Kurile Islands* • Chock — *Revision of Hawaiian* Sophora • Randall — *The Surgeon Fish Genus* Acanthurus • Notes

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PREPARATION OF MANUSCRIPT

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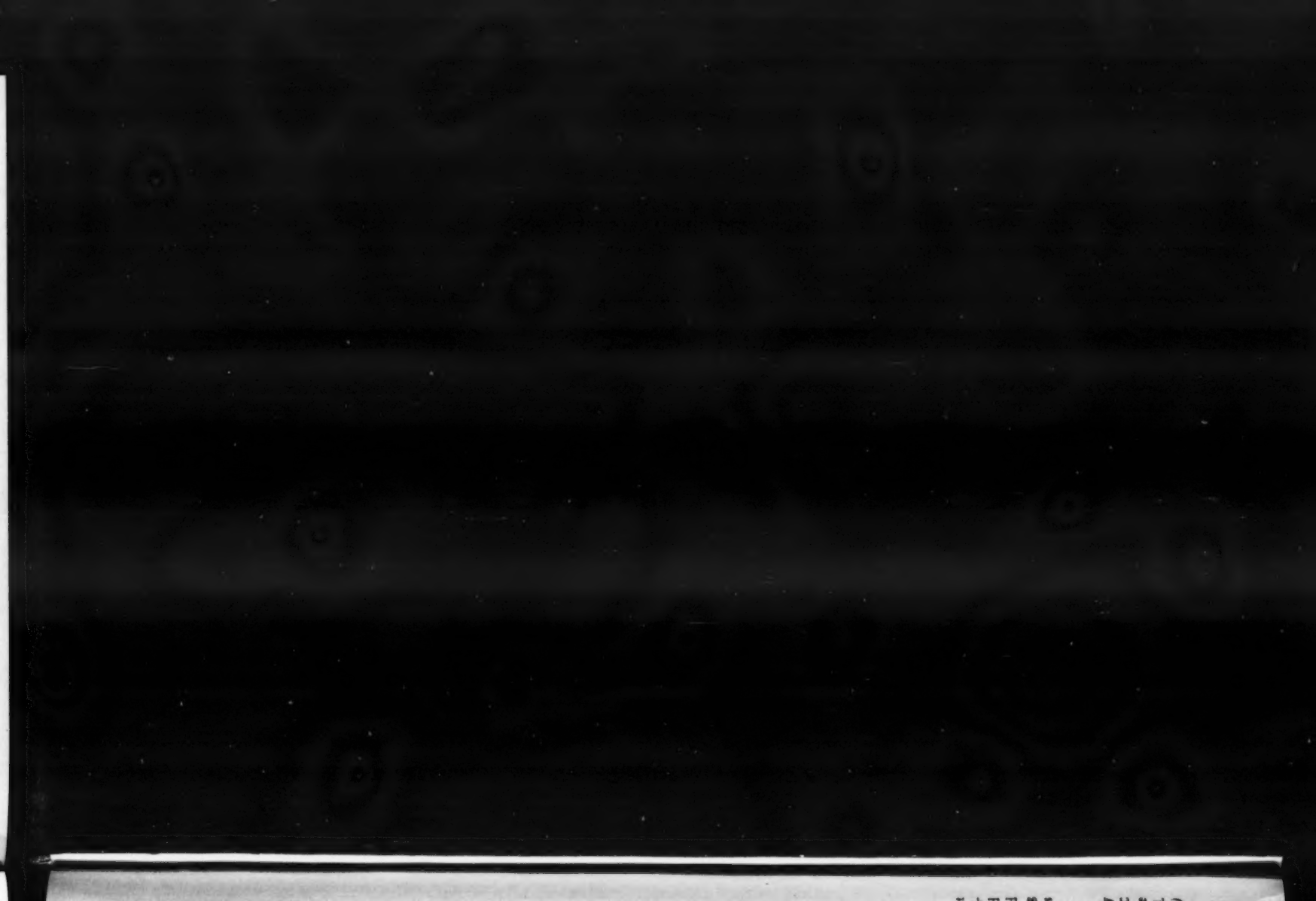
(Continued on inside back cover)



PACIFIC SCIENCE

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Cheilostomatous Bryozoa from the Kurile Islands and the Neighbouring Districts[1]

SHIZUO MAWATARI[2]

ABOUT A DOZEN YEARS have elapsed since Dr. Katsuzo Kuronuma very kindly placed his collection of Bryozoa from Kurile Islands at my disposal. Though I presented a preliminary report at the seventeenth annual meeting of the Zoological Society of Japan, the large part of my study on northern forms has been put away unpublished.

There have been only two papers published on the bryozoan fauna of the high northwestern Pacific, both by Dr. Y. Okada. In 1918 he described 10 species from Dr. H. Marukawa's collection from Kamtschatka, and later (1933) he published a brief account of 14 species collected by the Northern Kurile Expedition of the Biogeographical Society of Japan. Our knowledge of the bryozoan fauna of these districts remains, therefore, very incomplete at present. To prepare this brief report, then, I have made a thorough reexamination of the northern material both in Okada's possession and my own.

Specimens

1. From Kamtschatka, collected at spots near the estuary of the River Kishika by Dr. H. Marukawa, June 1912. Nos. 560–580.

2. Taken by the Northern Kurile Expedition of the Biogeographical Society of Japan, collected by Mr. K. Koba in 1931.
   Off Ichinowatashi, Alaid Island. Nos. 1400–1412.
   Kitaura, Alaid Island Nos. 1413–1415.
   Off Arakawa, Paramushir Island. Nos. 1416–1420.
   Torishima, Paramushir Island. Nos. 1421–1438.

3. From Paramushir Island, collected by Dr. K. Kuronuma at a spot 10 miles south of the Island, August 1942. Nos. 4000–4021.

4. A part of the following material from Hokkaido.
   Akkeshi, coll. by Iwasa, July 1938. Nos. 1200–1221.
   Samani, coll. by Kuronuma, March 1944. Nos. 4200–4218.
   Akkeshi, coll. by Tanaka, August 1944. Nos. 4219–4251.
   Akkeshi, coll. by Okada, July 1945. Nos. 4508–4519.
   Kushiro, coll. by Nagamine, July 1950. Nos. 6201–6367.

Study of these collections has shown 45 species (including 2 undetermined forms) belonging to 15 families and 32 genera to be present. Six of the species are described as new. The known distribution of the species included is given in Table 1. In spite of the

[1] Contributions from the Research Institute for Natural Resources. No. 729. Studies on the Bryozoan Fauna of Japan and Adjacent Waters. No. 2. Manuscript received March 31, 1955.

[2] The Research Institute for Natural Resources, Shinjuku, Tokyo, Japan.

TABLE 1
KNOWN DISTRIBUTION OF THE SPECIES OF CHEILOSTOMATOUS BRYOZOA FOUND IN THE NORTHWESTERN PACIFIC

	ATLANTIC				PACIFIC				
	Arctic Ocean	Scandinavia	Europe (Mediterranean)	N. America	Alaska	Canada	U.S.A.	Japan (excl. Hokkaido)	China, Philippine, Malay
Aetea anguina	+	+	+	+		+	+	+	+
Membranipora serrilamella				+		+	+	+	
Membranipora serrulata	+	+		+					
Conopeum reticulum		+	+		+	+	+	+	+
Electra crustulenta var. *arctica*		+							
Seculiflustra seculifrons	+	+	+	+					
Terminoflustra membranaceo-truncata		+			+	+			
Hincksina onychocelloides sp. nov.									
Antropora japonica								+	
Cauloramphus spiniferum		+			+	+	+	+	
Callopora lineata	+	+	+	+	+	+	+	+	
Tegella armifera	+	+		+	+	+	+	+	
Tegella unicornis	+	+	+	+	+	+	+		
Microporina articulata					+	+	+		
Tricellaria ternata	+	+	+				+	+	
Tricellaria erecta					+	+			
Tricellaria unyoi									
Scrupocellaria scabra	+	+	+	+	+			+	+
Watersia kishikaensis									
Bugula californica						+	+	+	
Bugula sp.									
Caulibugula aspinosa sp. nov.									
Dendrobeania kurilensis									
Hippothoa hyalina	+	+	+	+		+	+	+	+
Hippothoa expansa	+	+	+		+	+	+		
Hippothoa divaricata	+	+	+		+	+	+	+	
Petraliella sp.									
Stomachetosella sinuosa		+			+	+			
Umbonula arctica	+	+			+	+	+		
Schizoporella bidenkapi		+							
Codonellina operculata sp. nov.									
Porella mucronata sp. nov.									
Porella immersa sp. nov.									
Porella acutirostris	+	+	+		+				
Porella marukawai									
Porella concinna	+	+	+		+	+	+	+	
Porella kurilensis sp. nov.									
Smittina bella	+	+		+	+	+	+	+	
Parasmittina trispinosa var		+	+	+		+	+	+	+
Mucronella peachii	+	+		+	+	+		+	
Schizoretepora tumescens								+	
Siniopelta costazii		+	+	+		+	+	+	+
Siniopelta incrassata		+	+		+	+	+	+	
Myriozoum subgracile	+	+	+		+	+	+	+	
Myriozoella planum	+								

fact that the materials have been obtained from somewhat confined localities and consequently they cannot provide a sufficient basis for a full discussion of the bryozoan fauna of these districts, the table will give a general idea of the faunistic constitution of the high northwestern Pacific.

Excluding two uncertain forms and 12 restricted species, 27 of the remaining 31 are known to occur in the Arctic Ocean or in the northern part of the Atlantic, thus indicating the overwhelming influence of colder waters on the fauna of this district. It may be rather surprising that only three of the species belong to the circum-pacific group.

I should like to express here my cordial thanks to Drs. Y. Okada and K. Kuronuma who have given me an opportunity to examine their interesting collections.

The figures have been drawn with the aid of a camera lucida at magnifications of 50 or 200 diameters.

ANASCA

Family *AETEIDAE*

1. **Aetea anguina** (Linnaeus), 1758
Fig. 1*a*

Zoarium adherent, occasional by branching. Zooecia elongate, creeping, granulated proximally; erect, tubular, curved, annulate distally. Membranous area subterminal, slightly expanded, punctured dorsally. An empty membranous ovisac was observed on the frontal membranous area near the distal end.

SPECIMENS EXAMINED: No. 4011 (Paramushir), No. 4221 (Akkeshi), Nos. 6238, 6317 (Kushiro).

Family *MEMBRANIPORIDAE*

2. **Membranipora serrilamella** Osburn, 1950
Fig. 1*b*

Zoarium encrusting especially on wider algae. Zooecia nearly elongate-quadrangular, with thick walls and serrate cryptocyst, sometimes a longer spinule at the proximal end. A small hollow protuberance at each corner. Several specimens were obtained from the floating fronds of kelp.

SPECIMENS EXAMINED: No. 4013 (Paramushir), No. 4227 (Akkeshi), Nos. 6211, 6325 (Kushiro).

3. **Membranipora serrulata** (Busk), 1881

Colony erect, bilamellar, sometimes *Steganoporella*-like, rising from widespread unilamellar encrusting base. Zooecia variable in size, rectangular or elongate oval, with slight, granulate proximal cryptocyst, serrate marginally. Zooecial orifice rather large, subquadrangular. No spines, no avicularia and no ovicells. Two distal and two lateral rosette-plates. A pair of distinct opercular glands.

SPECIMENS EXAMINED: No. 566 (Kamtschatka), No. 6318 (Kushiro).

4. **Conopeum reticulum** (Linnaeus), 1767
Fig. 1*e*

Zoarium encrusting especially on broader algae, greyish white, thin, often gauze-like. Zooecia, variable, elongate quadrangular or hexagonal, separated by grooves or lines. Walls thickly calcified, high, smooth or denticulate. Cryptocyst narrow, descending, granulate, surrounding oval, elliptic or circular opesia. A pair of triangular knob-like spaces, depressed or closed, on the proximal corners of short gymnocyst. Irregular rounded spaces sometimes scattered. Ooecia and avicularia wanting.

SPECIMENS EXAMINED: No. 1405 (Alaid), No. 4019 (Paramushir), No. 4233 (Akkeshi), No. 6235 (Kushiro).

Family *ELECTRINIDAE*

5. **Electra crustulenta** var. **arctica** (Borg), 1931
Fig. 1*d*

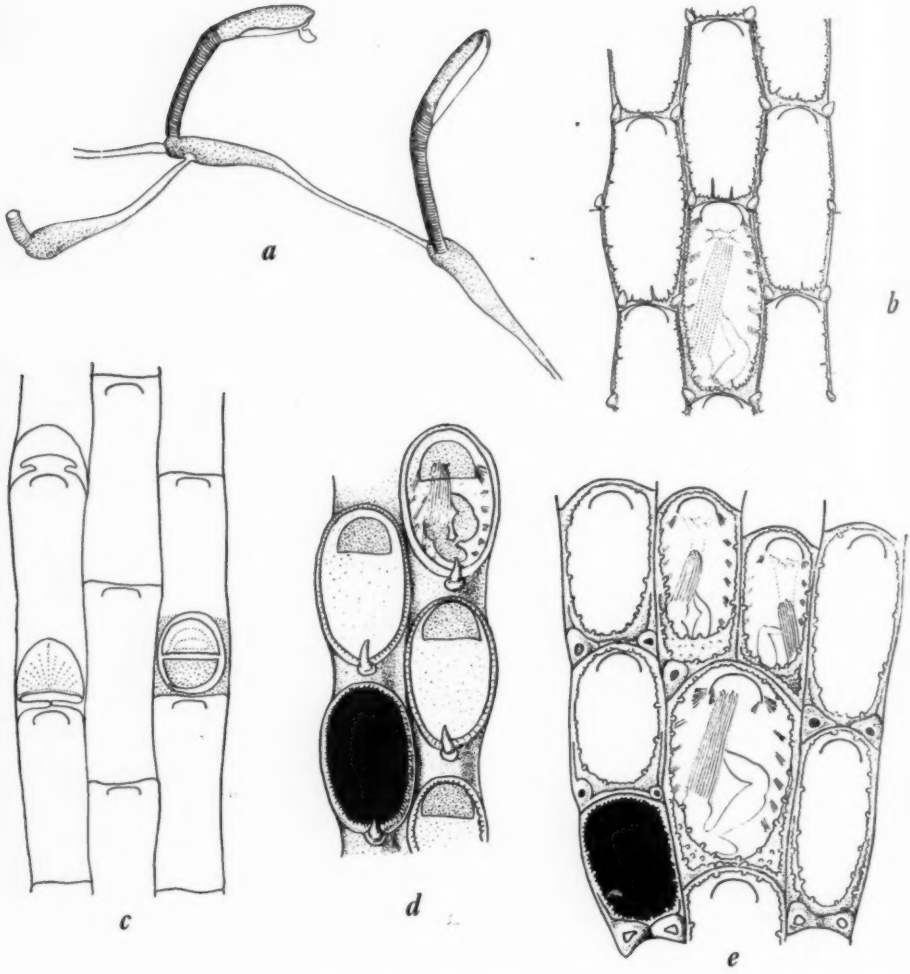

FIG. 1. *a*, *Aetea anguina* (Linnaeus); part of a creeping colony. *b*, *Membranipora serrilamella* Osburn; frontal view of zooecia with covering membrane. *c*, *Seculiflustra seculifrons* (Pallas); frontal view of zooecia, an interzooecial avicularium and two developing ooecia. *d*, *Electra crustulenta* var. *arctica* (Borg); zooecia with large calcified operculum. *e*, *Conopeum reticulum* (Linnaeus); frontal view of zooecia.

Zoarium encrusting, thin. Zooecia elliptical, separated by furrows, with thickened, granulate mural rim and vestigial cryptocyst. Gymnocyst smooth, developed, with a single strong spinous process rising just proximal to the opesia. Operculum calcified, white. Several specimens were obtained on shells and stones, they are easily distinguished by the calcified operculum and proximal process.

SPECIMENS EXAMINED: No. 1434 (Paramushir), Nos. 6215, 6217, 6336, 6341 (Kushiro).

Family *FLUSTRIDAE*

6. **Seculiflustra seculifrons** (Pallas), 1766
Fig. 1*c*

Zoarium erect, frondose, rather narrow, truncate terminally. Zooecia elongate-quadrangular or elongate-hexagonal, simple, without spines. Avicularia vicarious, rectangular basally, subcircular or oval in frontal view. Mandibles semi-elliptical, deep yellow. Ooecia immersed, oval, with radially striated frontal, closed with overarching lateral ribs.

SPECIMENS EXAMINED: No. 569 (Kamtschatka), No. 6281 (Kushiro).

7. **Terminoflustra membranaceo-truncata** (Smitt), 1867

Zoarium erect, unilaminar, thin, irregularly flabellate. Zooecia elongate hexagonal, truncate, with a minute spine at each distal corner. Avicularia square, mandibles semicircular. Ooecia endozooecial, small.

SPECIMENS EXAMINED: No. 1416 (Paramushir), No. 6201 (Kushiro).

Family *HINCKSINIDAE*

8. **Hincksina onychocelloides** sp. nov.
Fig. 2*a–c*

Zoarium encrusting, thin, coarse, irregular, dark brown. Zooecia oval or hexagonal, arranged alternately in radiating rows. Frontal membrane occupies the whole front bordered with thin, granulate, inclined walls and narrow marginal cryptocyst. Operculum (Fig. 2*c*) rather thickened marginally, low, transverse. Vicarious avicularia occurring in longitudinal rows, elongate-elliptic, without bar and conspicuous teeth. Mandible (Fig. 2*b*) elongate-triangular, with proximally bifurcate long median sclerite extending terminally beyond the membranous wing, similar to that of *Onychocella*. A single distal and two lateral rosette plates. Minute spinous processes on the dorsal wall, probably for attachment.

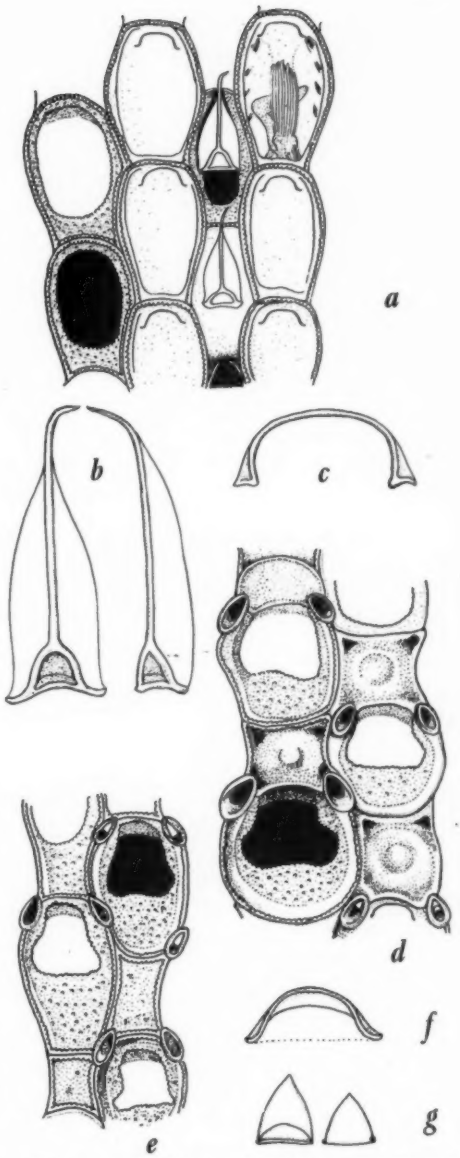

FIG. 2. *a–c*, *Hincksina onychocelloides* n. sp.: *a*, Frontal view of zooecia and two vicarious avicularia; *b*, avicularian mandibles with wings and produced median carina; *c*, operculum. *d–g*, *Antropora japonica* (Canu and Bassler): *d*, Frontal view of fertile zooecia with ooecia covering the interopesial spaces; *e*, young zooecia; *f*, operculum; *g*, delicate mandibles of dependent avicularia.

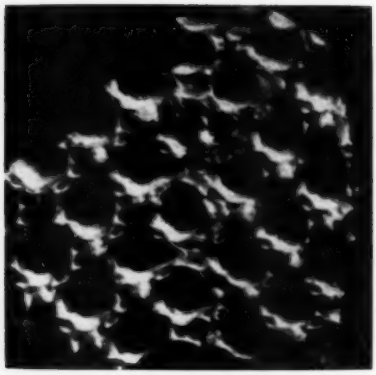

FIG. 3. *Antropora japonica* (Canu and Bassler), photomicrograph of calcined specimen.

This species is peculiar in having very wide opesia and *Onychocella*-type avicularian mandibles. It is somewhat doubtfully placed under *Hincksina*.

SPECIMENS EXAMINED: No. 4209 (Paramushir), Nos. 1206, 4223, 4513 (Akkeshi).

9. **Antropora japonica** (Canu and Bassler), 1929

Figs. 2*d–g*, 3

Membrendoecium japonicum Canu and Bassler (1929).

Zoarium encrusting, flat, irregularly lobate. Zooecia oval, hexagonal or quadrangular, very large, completely covered by brownish membrane. Frontal surrounded by thick, raised, granulate walls. Cryptocyst developed proximally, extending along the lateral walls, minutely granulate. Opesia nearly trifoliate, large, characteristic. Avicularium on a thickened protuberance at each distal corner, with pointed rostrum and delicate triangular mandible (Fig. 2*g*). Peculiar quadrangular interopesial area covered by membrane with or without separating walls. Fertile zooecia (Fig. 2*d*) larger and broader, with developed cryptocyst. Ooecium distinct, globose, umbonate, situated commonly on the quadrangular interopesial space. A single terminal pore-chamber with four multiporous rosette plates, and two pairs of lateral pore-chambers with multiporous rosette plates. Opercular valve (Fig. 2*f*) low and broad.

The type locality is near Cape Tsugaru (misprinted as Tsiuka). The species is to be classified in *Antropora* not in *Membrendoecium*.

SPECIMENS EXAMINED: Nos. 4005, 4006 (Paramushir).

10. **Cauloramphus spiniferum** (Johnston), 1838

Fig. 4*a*

Zoarium encrusting stones or shells. Zooecia moderately large, with raised gymnocyst. Opesia oval or elliptic. Cryptocyst slight, sometimes vestigial. Opesial spines moderate; 10 to 13 in number, overarching the opesia. A small pedicellate avicularium with minute mandible among spines on each side, but slightly outside of the row of spines. Ooecium probably wanting.

SPECIMENS EXAMINED: No. 4021 (Paramushir), No. 4201 (Samani), Nos. 6209, 6256 (Kushiro).

11. **Callopora lineata** (Linnaeus), 1768

Fig. 4*b*

Zoarium encrusting, unilaminar, irregular, brownish. Zooecia distinct, oval, with raised walls. Frontal membranous area reduced, gymnocyst developed proximally. Opesia oval, a little broadened proximally, with thickened margin. Opesial spines, three or six on each side, obliquely overarched. Cryptocyst very narrow, linear and granulate. A triangular, suboral avicularium usually on a prominent globular umbo. Ooecia large, globose, flattened frontally, always traversed by thickened rib, and usually surmounted by an avicularium.

SPECIMENS EXAMINED: No. 571 (Kamtschatka), No. 4001 (Paramushir), No. 4208 (Samani), No. 4229 (Akkeshi).

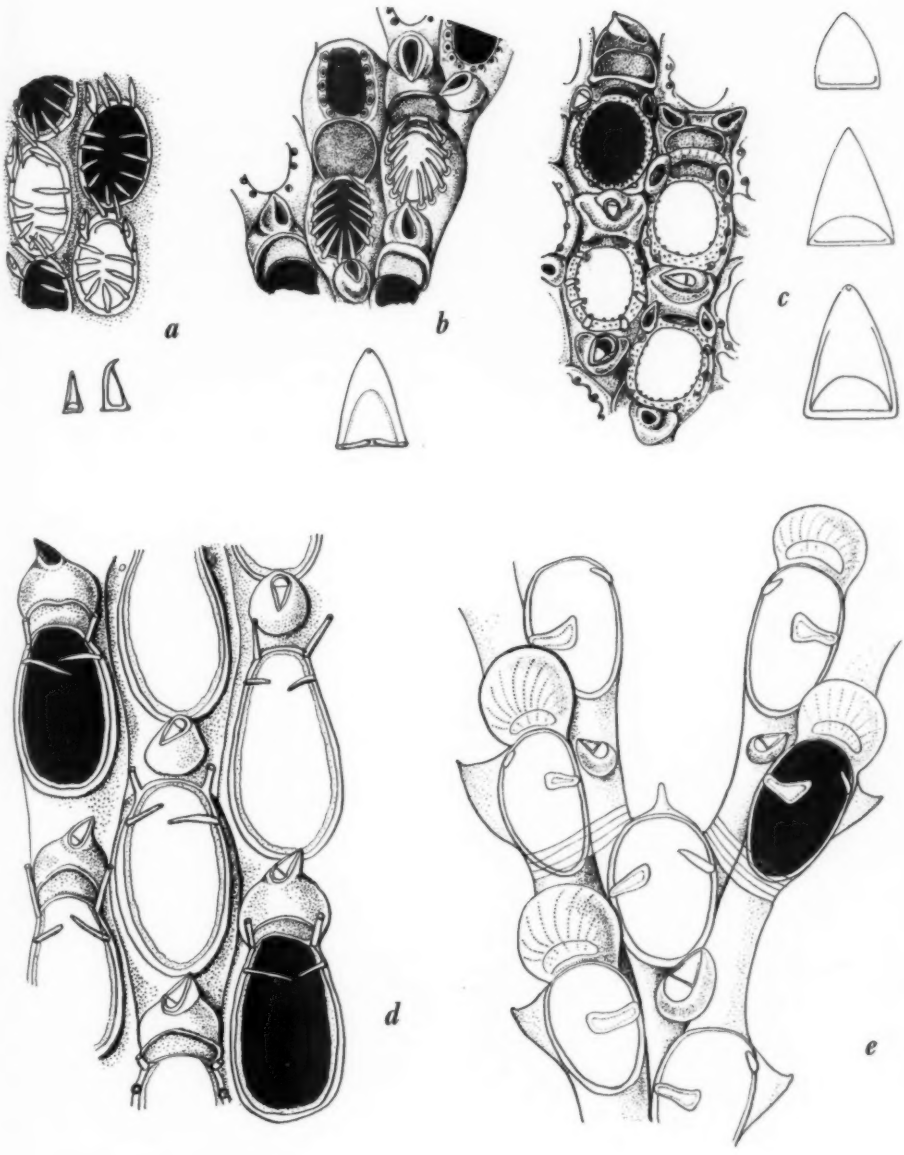

FIG. 4. *a*, *Cauloramphus spiniferum* (Johnston), frontal view of zooecia with spiniferous avicularia and minute mandibles of avicularia. *b*, *Callopora lineata* (Linnaeus), fertile zooecia with ooecia superposed by frontal avicularia and detail of mandible of frontal avicularium. *c*, *Tegella armifera* (Hincks), frontal view of fertile zooecia and details of mandibles of frontal avicularia. *d*, *Tegella unicornis* (Fleming), matured zooecia and frontal avicularia. *e*, *Tricellaria erecta* (Robertson), frontal view of diverging branches.

12. **Tegella armifera** (Hincks), 1880
Fig. 4*c*

Zoarium encrusting, pale brown or grey. Zooecia large, distinct, separated by furrows. Gymnocyst about one-third or one-half of the frontal, convex, with large suboral avicularium on a prominent umbo. Opesia large, broad, with granular marginal cryptocyst and raised borders. Two or four opesial spines on each side, and a raised lateral avicularium on each distal corner. Ooecia globose, with flattened frontal surface limited by a transverse bar. Suboral avicularium close to the preceding ooecium. Two distal and four lateral multiporous rosette plates.

The direction of lateral avicularia and the full number of opesial spines differ from Osburn's description (Osburn, 1950), thus suggesting a distinct variety.

SPECIMENS EXAMINED: No. 4020 (Paramushir), No. 6320 (Kushiro).

13. **Tegella unicornis** (Fleming), 1828
Fig. 4*d*

Zoarium encrusting, irregular, yellow or brown. Zooecia regularly arranged, moderate with raised walls. Gymnocyst less than one-third of the frontal length. Opesia oval, narrowed distally with thickened margin and narrow cryptocyst minutely serrate; four spines near the distal end of opesia. Ooecia large, elongate, globose, with distinct transverse rib. Suboral avicularium comparatively large, prominent on an umbo, triangular mandible extending obliquo-proximally. Marcus suggested that Okada's specimens might belong to *T. robertsonae* but my reexamination has proved the correctness of Okada's identification.

SPECIMENS EXAMINED: No. 561 (Kamtschatka), No. 1403 (Alaid), No. 4214 (Samani), No. 6033 (Kushiro).

Family *MICROPORIDAE*

14. **Microporina articulata** (Fabricius), 1821

Zoarium erect, dichotomously branching, articulated, Cellariiform, attached by rootlets. Internodes stout; zooecia around the zoarial axis, very elongated quadrangular, separated by furrows. Frontal flat, thick, minutely perforate and occasionally granulate, encircled by salient ridges. Opesia semicircular or semielliptic, with straight proximal border. Opesiules small, rather indistinct, slit-like. Avicularia oval, prominent, limited by salient ridges, immersed at the proximal end of the zooecium. Ovicells endozooecial.

SPECIMENS EXAMINED: No. 1409 (Alaid), No. 1425 (Paramushir), No. 6231 (Kushiro).

Family *SCRUPOCELLARIIDAE*

15. **Tricellaria ternata** (Solander), 1786

Zoarium erect, white, bushy, expanded or confervoid. Branches straggling, internodes consisted of three to five zooecia. Chitinous joint traversing the base of both inner and outer zooecia proximally to the opesia. Zooecia slender, much attenuated below, with elliptic opesia. Scutum variable from a mere spine to spatulate plate. One or two inner and two or three outer spines on the distal margin. A small frontal avicularium on the axial zooecium. Lateral avicularium large and prominent. Ooecia large, globose rather elongate and imperforate. Radical fibres from a circular disc outside the opesia. Long claspers from a small chamber above the lateral avicularium, enlarged terminally.

SPECIMENS EXAMINED: No. 1410 (Alaid), Nos. 1422, 1436 (Paramushir), No. 6321 (Kushiro).

16. **Tricellaria erecta** (Robertson), 1900
Fig. 4*e*

Zoarium erect, with very long branches rather like that of *Scrupocellaria*. Zooecia biserial, attenuate proximally, with crenulate, raised margins and one or two spines at the outer corner. Scutum rather narrow, spatulate, occasionally broad and bifid; frontal avicularia generally on each zooecium, lateral avicularia

variable, often vestigial. Ooecia globose, striated and fenestrated. Joint traversing the base of the outer opesia.

SPECIMENS EXAMINED: No. 1419 (Paramushir), No. 4213 (Samani).

17. **Tricellaria unjoi** (Okada), 1918

Zoarium bushy, 2–3 cm. in height, milky white (in spirits). Branches delicate, biserial, internodes of three to five or five to nine zooecia. Zooecia elongate, narrowed proximally, with elliptic opesia. Two short spines on the outer opesial margin; scutum varying from a spinous process to a spatula. Marginal avicularia large, frontal avicularia wanting. Rootfibres from small chambers above the avicularia. Ooecia oval, globular, smooth with faint striations and peculiar elliptic median fenestra.

SPECIMEN EXAMINED: No. 565 (Kamtschatka).

18. **Scrupocellaria scabra** (van Beneden), 1848

Zoarium erect, bushy, stout. Internodes long, three to ten or more zooecia in a series. Joint traversing just proximally to the outer opesia or slightly involving it. Zooecia elongate, with curved outer margin. Opesia about half of the frontal length, oval, with developed cryptocyst and raised margin. Scutum very large, oval or flared, with branched internal cavity. A small inner spine and one or two outer spines on the distal corners. Marginal avicularia large, conspicuous on all of the zooecia. The frontal avicularia small, rather rare. Vibracula small, rather inconspicuous, transverse, above the avicularian chamber with transverse groove. Flagellum shorter than zooecia, somewhat stout, often wanting.

Ooecia subglobose, with striate triangular area on the front.

SPECIMENS EXAMINED: No. 1429 (Paramushir), No. 1211 (Akkeshi).

Family *BIALLARIELLIDAE*

19. **Watersia kishikaensis** (Okada), 1918
Fig. 5*a*

Flustra episcopalis var. *simplex* Okada (1917).
Flustra simplex var. *kishikaensis* Okada (1918).
Euthyroides simplex var. *kishikaensis* Okada (1921).

Zoarium erect, frondose, fan-shaped, bilaminar. Branches widened distally to the subtruncate end. Zooecia elongate-quadrangular, narrow; marginal kenozooecia much elongated. Orifice subterminal, broad, closed by opercular valve. Avicularia vicarious, elongate oval with radiating frontal striations and quadrangular base; mandible semicircular, broad.

Ooecia large, prominent, distinctly carinate, with paired elliptic fenestra and faint radiating lines.

SPECIMENS EXAMINED: No. 579 (Kamtschatka), No. 6290 (Kushiro).

20. **Bugula californica** Robertson, 1905

Zoarium erect, thick, bushy. Opesia about two-thirds of the frontal, with two to four short, stout spines on the distal corners. Avicularia large, robust, a little distal to the middle of the outer wall. Ancestrula with a median suboral spine and three or five distal spines. Ooecia unknown.

SPECIMEN EXAMINED: No. 4016 (Paramushir).

21. **Bugula** sp. undet.

Zoarium erect, bushy, delicate and small. Zooecia slender, with short proximal gymnocyst and truncate distal end. Opesia occupies the larger part of the frontal, with two outer and one inner spines on the corner. Avicularia small, rounded or elliptic, near the proximal end of the opesia on the outer wall. Ooecia globose, attached to the middle line. Rootlets numerous.

As the specimens are all fragmentary, the determination is postponed until more complete material is obtained.

SPECIMENS EXAMINED: No. 1207 (Akkeshi), No. 1428 (Paramushir).

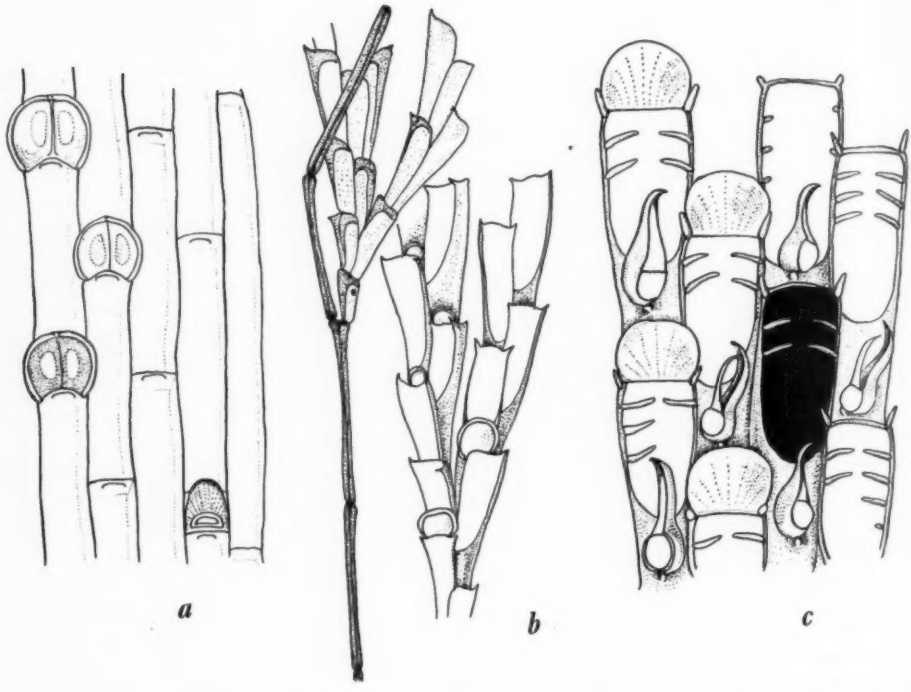

FIG. 5. *a*, *Watersia kishikaensis* (Okada), frontal view of marginal part of a lobate branch; elongated marginal kenozooecium, vicarious avicularium and fertile zooecia with carinate globose ooecia. *b*, *Caulibugula aspinosa* n. sp., keeled stem-kenozooecia, origin of functional branches and fertile internodes with ovicelled zooecia are indicated. *c*, *Dendrobeania kurilensis* (Okada), fertile part of an internode; striated ooecia and long beaked frontal avicularia are figured.

22. **Caulibugula aspinosa** sp. nov.
Fig. 5*b*

Zoarium erect, biserial, delicate, bushy on a slender stem. Proximal kenozooecia of the stem elongate, tubular, strengthened by longitudinal ribs. Autozooecia elongate-quadrangular, attenuate below, truncate or a little oblique distally. Opesia large, occupying the large part of the frontal, without long spines but with a short process at each distal corner, sometimes wanting. Avicularia moderate, elliptic, on the proximal gymnocyst but rather rare. Ooecia prominent, attached near the distal inner corner of the fertile zooecia.

The present species clearly belongs to *Caulibugula*, but is rather peculiar inasmuch as it lacks long spines. The general form of the zooecial tuft is very close to that of *Bugula*.

SPECIMENS EXAMINED: No. 1402 (Alaid), No. 4512 (Reisui).

23. **Dendrobeania kurilensis** (Okada), 1933
Fig. 5*c*

Bugula japonica kurilensis Okada (1933).

Zoarium frondose, multiserial, without connecting tubes. Zooecia with a distal process and one to four spines on each lateral wall. Median proximal avicularia moderate, with peculiarly long, curved beak. Ooecia mod-

erate. The long curved avicularian rostrum is peculiar.

SPECIMENS EXAMINED: No. 1407 (Alaid), Nos. 4228, 4519 (Monsei).

ASCOPHORA

Family *HIPPOTHOIDAE*

24. **Hippothoa hyalina** (Linnaeus), 1767

Zoarium encrusting, thin, hyaline, glistening or multilameller, irregularly piled up, rough, opaque. Zooecia more or less separated, pyriform, convex, transversely ribbed, encircled by a row of fenestrae. Orifice terminal, circular, with rounded shallow sinus and thin peristome. Female zooecia a little smaller, male zooecia minute, occurring irregularly, with marginal perforations and branching suture.

SPECIMENS EXAMINED: No. 564 (Kamtschatka), No. 1418 (Paramushir), No. 4014 (Paramushir), No. 4217 (Samani), No. 4238 (Akkeshi), No. 6203 (Kushiro).

25. **Hippothoa expansa** Dawson, 1859
Figs. 6*a–e*, 7*a*, *b*

Zoarium thin, flat, flabellate or palmate, branched. Zooecia arranged in two or three rows, elliptic or pyriform, convex, with developed basal expansion and strong, transverse striations. Orifice subcircular, with broad shallow sinus closed by operculum (6*e*). Fertile zooecia shorter, with orifice straight proximally. Ooecium (6*c*) large, globose, broad, umbonate, thickened marginally. Operculum of fertile zooecium (6*d*) semicircular, that of ordinary zooecia with proximal projection. Interesting connecting tubes (6*b*) are seen in optical section.

Occurrence of two types of opercula is the most striking feature to distinguish this species from *H. divaricata*.

SPECIMENS EXAMINED: No. 4007A (Paramushir), No. 6301 (Kushiro).

26. **Hippothoa divaricata** Lamouroux, 1821
Figs. 6*f–h*, 7*c*

Zoarium creeping, uniserial, branched, ramose, delicate. Zooecia elongate-pyriform, convex, very slightly striated with narrow basal expansion and longitudinal carina. Orifice rounded, with broad sinus. Fertile zooecium smaller, with similar orifice and operculum (6*g*) to those (6*b*) of ordinary one. Ooecia globose (6*g*), smooth, slightly umbonate. Zoarial arrangement and zooecial form somewhat variable. Because of these variations the varietal names *conferta* and *carinata* have been proposed.

SPECIMENS EXAMINED: Nos. 1431, 4007B, 4018 (Paramushir), No. 4212 (Samani), No. 1218 (Akkeshi), No. 6290 (Kushiro).

Family *PETRALIIDAE*

27. **Petraliella** sp.
Fig. 8*a–c*

Zoarium encrusting, thick, greyish white. Zooecia moderate, oval or hexangular, arranged alternately. Frontal convex, rather reticulate or ribbed with infundibular pores. Orifice and operculum (8*b*) very large, semi-elliptic or subquadrangular with straight lateral and proximal margins. A large, elliptic avicularium with semi-elliptic mandible (8*c*) on a salient suboral mucro.

The species resembles in general appearance *Cryptosula pallasiana* and *Petraliella armata*, but differs in the large orifice and semicircular mandible. The specimen is not complete, being without ovicells. It is tentatively referred to *Petraliella*.

SPECIMEN EXAMINED: No. 1427 (Alaid).

Family *SCHIZOPORELLIDAE*

28. **Stomachetosella sinuosa** (Busk), 1860
Figs. 8*d*, *e*, 9

Zoarium encrusting, circular, thick, dark reddish brown or brownish purple. Zooecia hexagonal or elliptic, with rather sinuate mar-

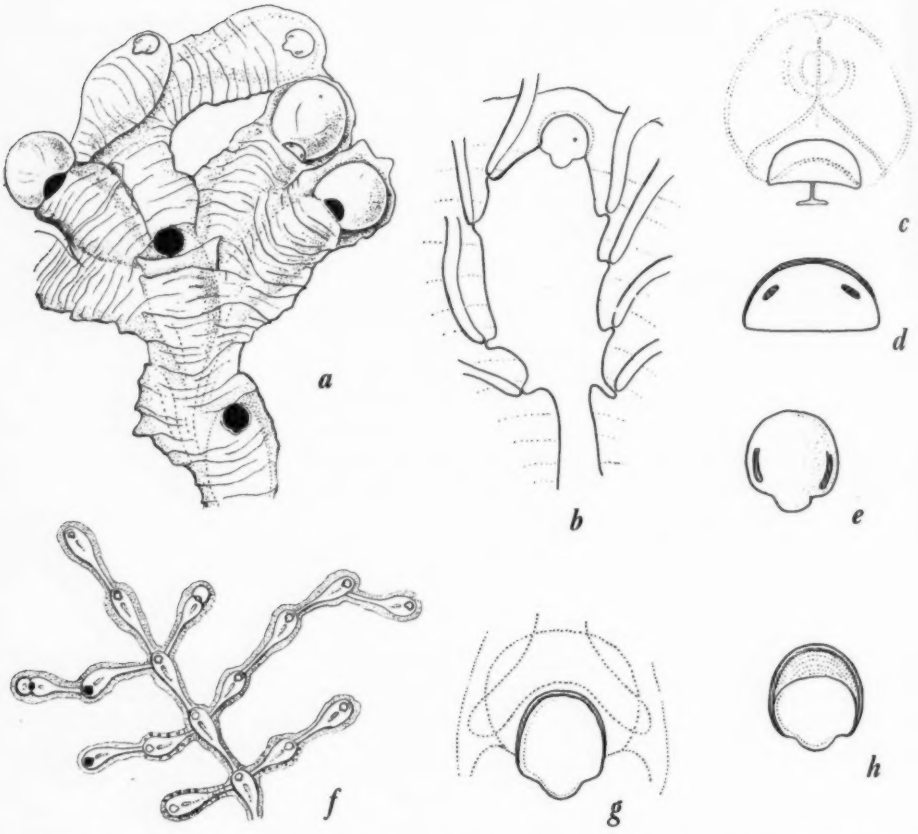

FIG. 6. *a–e*, *Hippothoa expansa* (Dawson): *a*, Part of an incrusting zoarium with semiglobular ooecia; *b*, basal view of a zooecium, indicating the connecting tubes; *c*, structure of an ooecium and aperture; *d*, operculum of a fertile zooecium; *e*, operculum of an immatured zooecium. *f–h*, *Hippothoa divaricata* Lamouroux: *f*, Frontal view of a branching colony; *g*, structure of fertile zooecium with ooecial cavity and the proximal end of the succeeding zooecium; *h*, operculum.

gin. Frontal thick, granular, convex or immersed, with large infundibular pores. Orifice circular or transversely elliptic with thin, pyriform peristome. No spines, no avicularium. Ooecia large, deeply immersed, with circular median pore. Four lateral and two distal multiporous rosette plates, Operculum (8*e*) circular, with proximal projection and lateral muscular insertions.

This is the *Schizoporella sinuosa* of various authors.

SPECIMENS EXAMINED: No. 1421 (Paramushir), No. 4226 (Akkeshi).

29. **Umbonula arctica** (M. Sars), 1851

Zoarium encrusting or foliaceous, unilamellar or bilamellar. Zooecia large, oval, quincuncial, convex, elevated distally. Frontal ribbed, areolate. Orifice large, orbicular with low peristome and suboral small mucro. A small avicularium with rounded mandible on

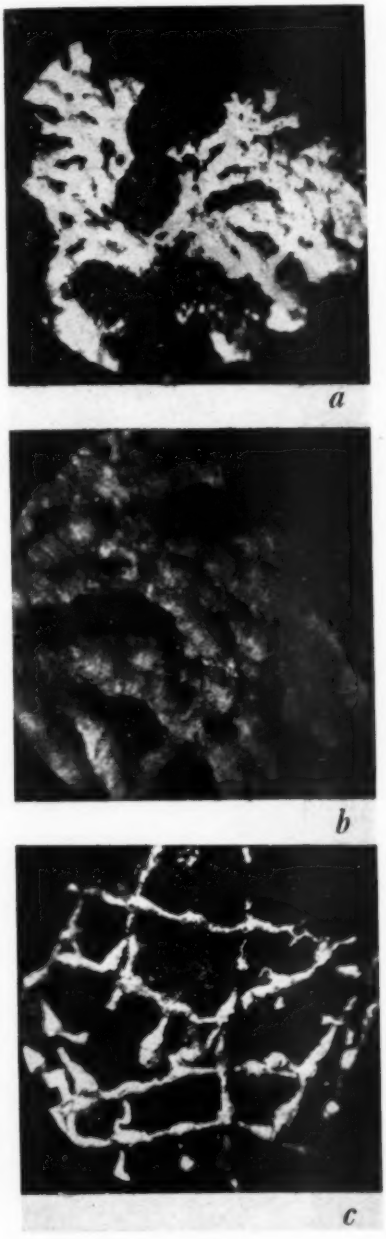

FIG. 7. Photomicrographs of calcined specimens of: *a*, *b*, *Hippothoa expansa* Dawson; *c*, *H. divaricata* Lamouroux.

each side of the orifice. Ooecia large, globose, immersed.

SPECIMENS EXAMINED: No. 1400 (Alaid), No. 4012 (Paramushir), No. 4216 (Samani), No. 6305 (Kushiro).

30. **Schizoporella bidenkapi** Nordgaard, 1902

Figs. 8*f*, *g*, 9

Colony encrusting, circular, thick. Zooecia large, hexagonal or quadrangular, with salient separating threads. Frontal thickened tremocyst, granular. Immersed orifice transverse, elliptic, produced proximally. Peristome deep, with circular orifice. Operculum (8*g*) subquadrangular with arched distal margin and incomplete lateral sclerites. Two distal and four lateral rosette plates. Avicularia wanting or vestigial, immersed, with minute mandible (8*g*).

SPECIMEN EXAMINED: No. 4004 (Paramushir).

Family *SMITTINIDAE*

31. **Codonellina operculata** sp. nov.

Figs. 8*b–k*, 9

Zoarium encrusting, thin, irregular, white and shining or pale purplish brown. Zooecia elongate elliptic or hexagonal separated by salient threads, slightly convex, smooth, perforated by regular circular pores. Orifice subcircular, with large sinus limited by broad cardelles, surrounded by thin peristome. Median suboral avicularium large, subquadrate, spatulate. Ooecium globular, perforate and marginate, bordered by peristome proximally. Operculum (8*i*) with submarginal short sclerites. Mandible (8*j*) with bifurcate median sclerite. Two distal and four lateral multiporous rosette plates (8*k*).

The species is allied to *Codonellina spatulata* (Okada and Mawatari), but is distinctly separated by its operculum and mandible.

SPECIMENS EXAMINED: No. 4015 (Paramushir), No. 4205 (Samani), Nos. 4219, 4517 (Akkeshi).

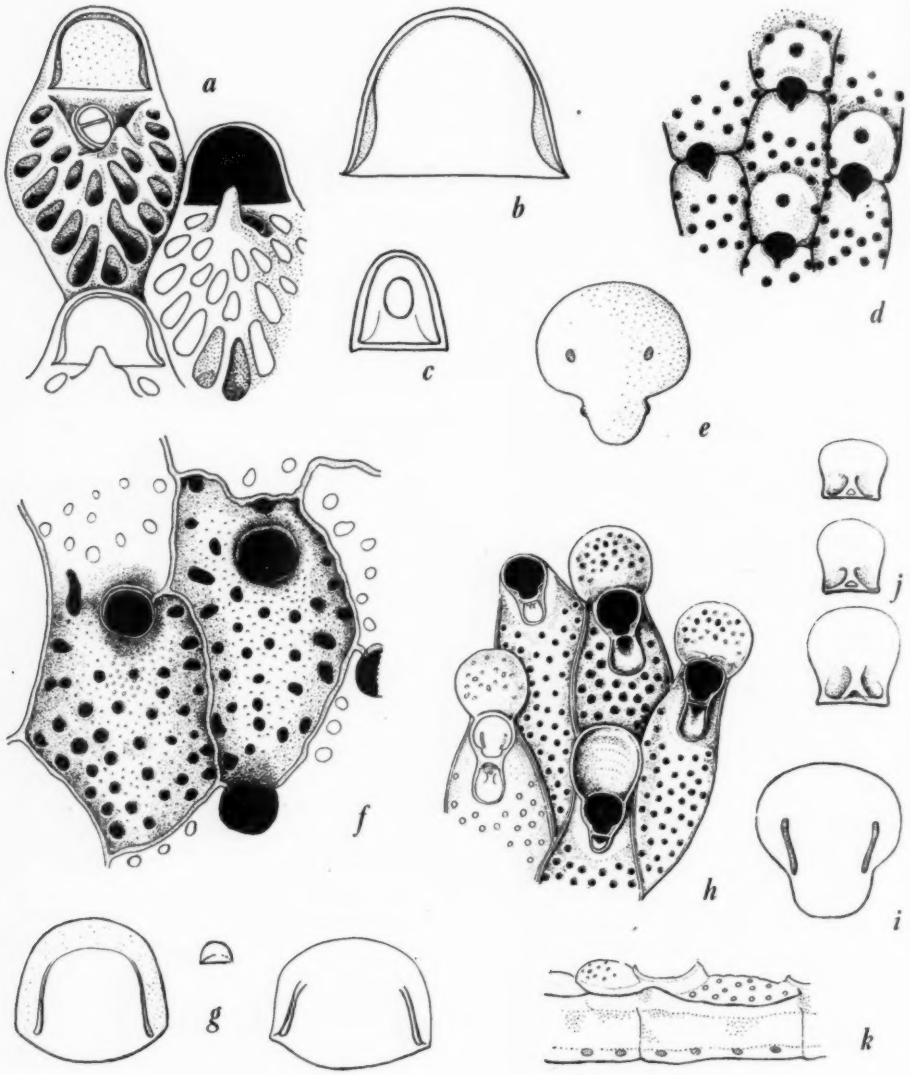

FIG. 8. *a–c*, *Petraliella* sp.: *a*, Frontal view of zooecia with subopecial process and an avicularium; *b*, operculum; *c*, mandible of the frontal avicularium. *d*, *e*, *Stomachetosella sinuosa* (Busk): *d*, Zooecia with perforated ooecia; *e*, operculum. *f*, *g*, *Schizoporella hidenkapi* Nordgaard: *f*, Frontal view of zooecia; *g*, two opercula and a minute mandible of rare frontal avicularium. *h–k*, *Codonellina operculata* n. sp.: *h*, Frontal view of fertile zooecia with porous ovicells; *i*, operculum; *j*, frontal mandibles; *k*, lateral view of a zooecium.

32. **Porella mucronata** sp. nov.
Figs. 10*a–d*, 11*a*

Zoarium erect, branched, flattened or thickened, bilaminar or multilaminar. Zooecia large, oval or hexagonal, globose, becoming immersed with age. Frontal thick pleurocyst, with small number of deep areolar pores and submedian, suboral mucro supporting a circular avicularium. Orifice very large, semicircular or subquadrangular, deeply immersed in the thickened peristome. Peristomial orifice with sinus. Ooecium globose, deeply immersed, opening into the peristome but not closed by operculum. Two lateral and one distal multiporous rosette plates. Operculum (10*b*) with strong lateral sclerites; mandible (10*c*) with marginal denticles. Large avicularian cavity is figured in section (10*d*).

The frontal pleurocyst, non-perforate ooecia, and suboral, submedian avicularia appear to me to indicate the position of the species near *Porella*.

SPECIMENS EXAMINED: No. 1413 (Alaid), No. 4210 (Samani).

33. **Porella immersa** sp. nov.
Figs. 10*e–g*, 11*b*

Zoarium disciform, dark brown or purple. Zooecia elliptic, subhexagonal, separated by furrows. Frontal convex pleurocyst, minutely granular with 8 to 13 small areolar pores. Orifice subcircular, with broad shallow sinus, concealed within a deep peristome. A small circular suboral avicularium on the raised frontal wall. Ooecia deeply immersed and concealed rather completely. Operculum (10*e*, *f*) subcircular with thickened margins and muscular insertions. Mandibles (10*g*) semicircular with bifurcate median sclerite.

SPECIMENS EXAMINED: No. 4017 (Paramushir), No. 1209 (Akkeshi), No. 4207 (Samani).

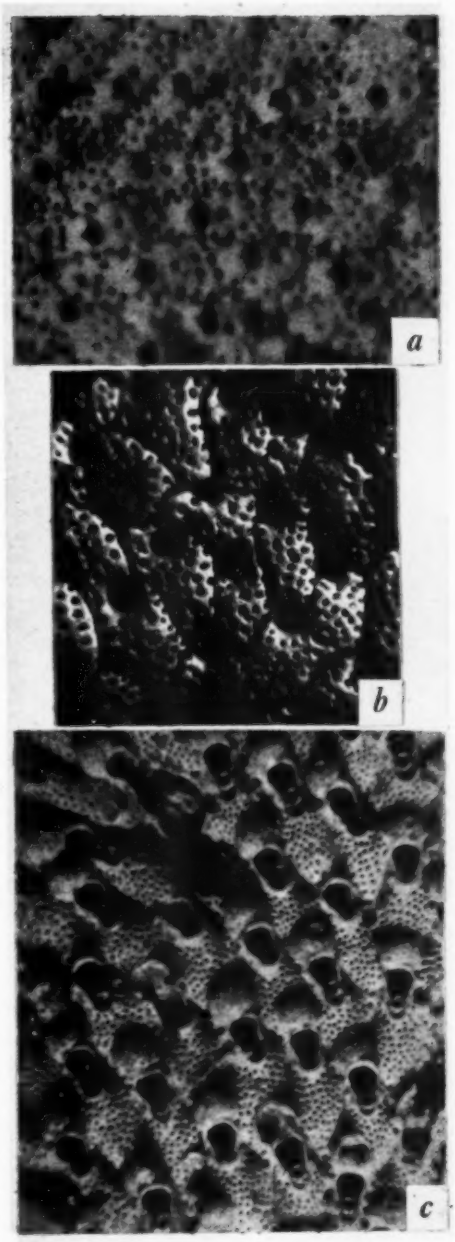

FIG. 9. Photomicrographs of calcined specimens of: *a*, *Stomachetosella sinuosa* (Busk); *b*, *Schizoporella bidenkapi* Nordgaard; *c*, *Codonellina operculata* n. sp.

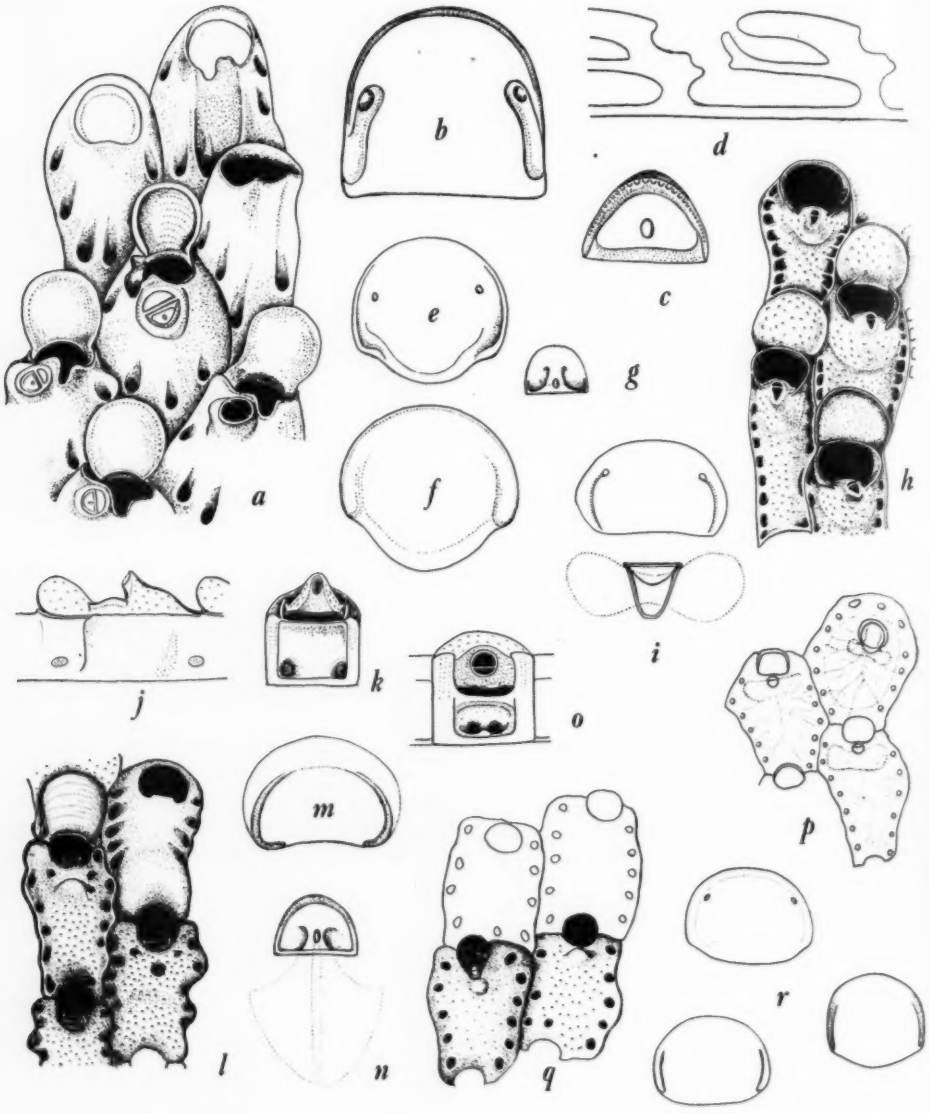

FIG. 10. *a–d*, *Porella mucronata* n. sp.: *a*, Frontal view of a part of the colony near the growing margin indicating the development of ooecia and peristomes; *b*, operculum; *c*, serrated avicularian mandible; *d*, longitudinal section of zooecia and avicularia. *e–g*, *Porella immersa* n. sp.: *e*, Operculum of ovicelligeous zooecium; *f*, operculum of immature zooecium; *g*, mandible of the frontal avicularium. *h–k*, *Porella acutirostris* Smitt: *h*, Fertile zooecia and ooecia; *i*, operculum, mandible and avicularian gland; *j*, lateral view of zooecia; *k*, distal view of a zooecium. *l–o*, *Porella concinna* (Busk): *l*, Frontal view of zooecia and ooecia; *m*, operculum; *n*, mandible of a subopesial avicularium; *o*, distal view of a zooecium. *p–r*, *Porella kurilensis* n. sp.: *p*, Frontal view of young zooecia; *q*, calcified zooecia; *r*, opercula.

34. **Porella acutirostris** Smitt, 1867
Fig. 10*b–k*

Zoarium encrusting, disciform, irregular. Zooecia elongate-hexagonal or oval, separated by salient threads. Frontal slightly convex, smooth or granular, with five to eight pairs of areolar pores, more or less reticulate in appearance. Orifice semicircular, somewhat straight proximally, surrounded by thin, raised, collar-like peristome. Avicularium is median, suboral, acute, on a prominent umbo including broad chamber (10*i*). Ooecia large, prominent, globose, granulate but imperforate. Two distal and two lateral multiporous rosette plates (10*j*, *k*). Operculum (10*i*) semicircular with muscular attachment. Mandible (10*i*) triangular, blunt, with thin marginal sclerite.

SPECIMENS EXAMINED: No. 575 (Kamtschatka), No. 4000 (Paramushir).

35. **Porella marukawai** Okada, 1918

Zoarium encrusting, unilamellar. Zooecia hexagonal or elongate-quadrangular, usually arranged in quincunx. Frontal wall thick, reticulate in appearance with shallow infundibuliform pores. Orifice nearly circular with shallow sinus limited with a pair of minute condyles. Orificial margin raised proximally into the suboral avicularian umbo supporting a small median avicularium with semicircular mandible. Ooecia large, globular, a little broader than long, distinctly descending proximally into the orifice. The surface divided by a transverse line, the proximal half with scattered pores of irregular shape and size.

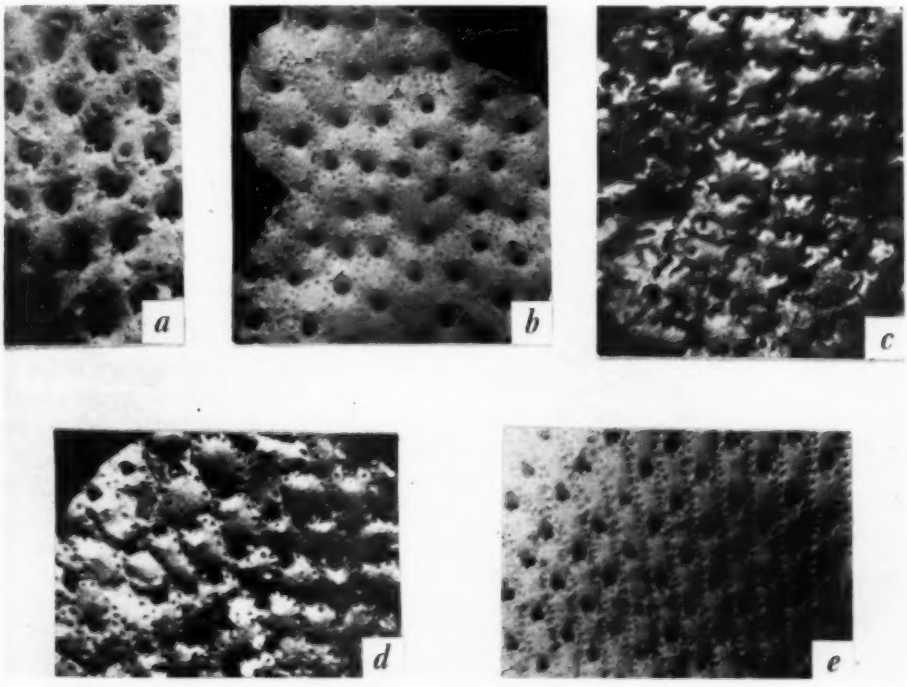

FIG. 11. Photomicrographs of calcined specimens of: *a*, ***Porella mucronata*** n. sp.; *b*, ***P. immersa*** n. sp.; *c*, ***P. concinna*** (Busk); *d*, *e*, ***P. kurilensis*** n. sp.

SPECIMEN EXAMINED: No. 572 (Kamtschatka).

36. **Porella concinna** (Busk), 1854
Figs. 10*l–o*, 11*c*

Zoarium encrusting, thin, opaque. Zooecia ovate, convex, granular with areolar pores. Zooecial margin more or less sinuate. Orifice orbicular, more or less straight proximally, with distinct lyrula. Peristome thick, high, enclosing zooecial orifice at its bottom. A median suboral avicularium circular or elliptic, within the lower margin of the peristome, sometimes hidden by avicularian umbo. Ooecia globose, often half immersed, rarely with median pore. Operculum transversely elliptic with slightly concave proximal margin; mandible semicircular, typical with median fenestrae.

SPECIMENS EXAMINED: No. 4010 (Paramushir), No. 4208 (Samani), Nos. 4237, 4515 (Akkeshi).

37. **Porella kurilensis** sp. nov.
Figs. 10*p–r*, 11*d*, *e*

Zoarium encrusting, irregular, thin, delicate. Zooecia quadrangular or hexagonal, granular, convex, five to eight areolar pores on each side. Orifice subcircular, transverse with concave, proximal margin. Peristome thin, slight. Avicularian umbo with transverse inner chamber just proximal to the orifice, supporting a circular or oval avicularium. A distal and two pairs of lateral pore-chambers with multiporous rosette plates. Operculum (10*r*) semi-elliptic, with incomplete marginal thickenings; mandibles minute, semicircular. Ooecia prominent, globose without perforations. The species is similar to some other *Porella*, but differs from them all in its operculum and mandibles.

SPECIMENS EXAMINED: Nos. 1424, 4010B (Paramushir).

38. **Smittina bella** (Busk), 1860
Figs. 12*a–e*, 13

Zoarium moderately thick, encrusting, irregular. Zooecia hexangular, or elongate-quadrangular, convex, granular, punctured. Orifice semicircular or elliptic, transverse, at the bottom of the rather deep peristome with rounded orifice. A proximal median lyrula small, supporting an elliptic operculum. A suboral avicularium median, small, on the raised part with inner transverse cavity. Operculum (12*d*) elliptic. Mandible (12*e*) spatulate, quadrangular. Ooecia globose, immersed, not punctate. Two distal and four lateral rosette plates (12*c*) with narrow tubular passages (12*b*) are figured.

SPECIMENS EXAMINED: No. 1401 (Alaid); No. 1430 (Paramushir); Nos. 4003B, 4008B (Paramushir); No. 4218 (Samani); No. 6261 (Kushiro).

39. **Parasmittina trispinosa** (Johnston), 1825 var.
Fig. 12*f*, *g*

Zoarium encrusting, irregular, thin. Zooecia hexagonal or quadrangular with salient separating threads. Frontal smooth or granulate, slightly convex, with five to eight areolar pores. Orifice circular, imbedded in the shallow peristome, with lyrula and small cardelles (12*g*). Peristomial orifice circular often raised distally, with two or three distal spines. Avicularia oval, rather large with hinge bar situating laterally or proximally on the frontal. Operculum circular with nearly straight proximal border, mandible is spatulate, or semi-elliptic. The specimen at hand differs slightly from the typical species and from other known varieties.

SPECIMEN EXAMINED: No. 4003D (Paramushir).

40. **Mucronella peachii** (Johnston), 1847
Figs. 12*b*, 13

Zoarium thick, disciform, pale brownish. Zooecia distinct, oval or hexagonal, convex, smooth or granular with prominent suboral mucro and small number of areolar pores.

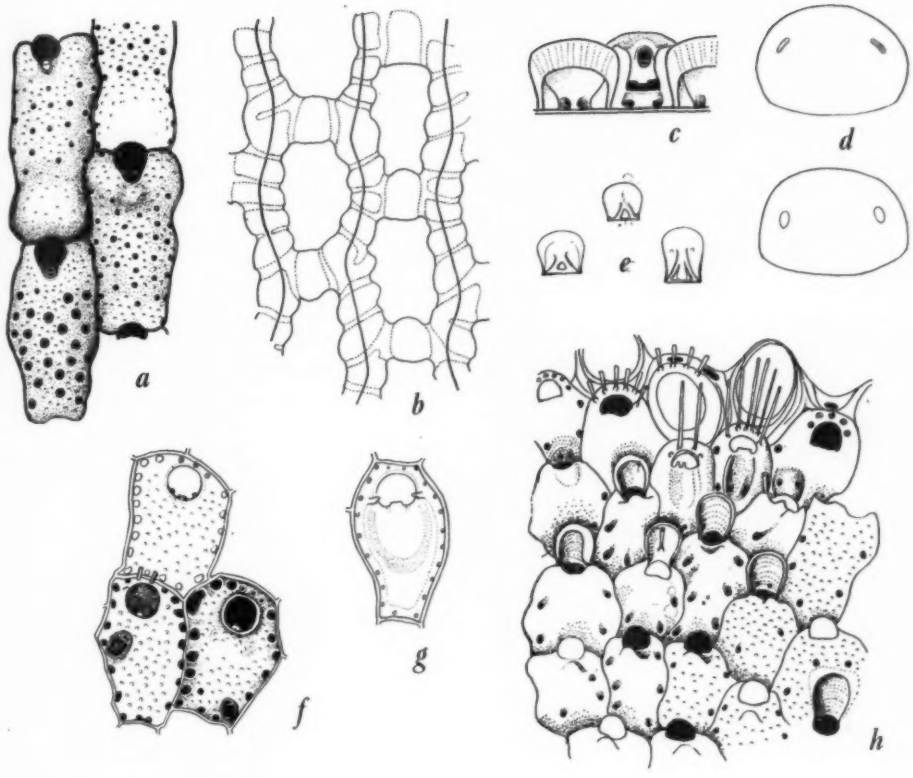

FIG. 12. *a–e*, *Smittina bella* (Busk): *a*, Zooecia with immersed ooecia; *b*, basal view of zooecia indicating communication system; *c*, distal view of zooecia; *d*, opercula; *e*, mandibles of peristomial avicularia. *f*, *g*, *Parasmittina trispinosa* (Johnston) var.: *f*, Frontal view of young zooecia; *g*, internal aspect of a zooecium. *h*, *Mucronella peachii* (Johnston), frontal view of the growing margin of a colony indicating the development of the ooecia, forming of the peristome and the disappearance of the spines.

Orifice semi-elliptic, rather large, straight proximally, with median lyrula. Peristome developed, thick, covering the orifice. Six spines on the distal border of the orifice, long, articulated basally. A longitudinal depressed area at the middle of the frontal, later covered by mucro. Two distal and four lateral multiporous rosette plates. Ooecia globose, half immersed.

SPECIMEN EXAMINED: No. 4003A (Paramushir).

Family *RETEPORIDAE*

41. **Schizoretepora tumescens** (Ortmann), 1890

Fig. 14*a–g*

Retepora tumescens Ortmann (1890).

Zoarium of usual *Reteporella* type, rather thick, with small elliptic fenestrae. Zooecia facing internally to the cup-shaped colony, elongate-hexagonal, convex, granulate, with

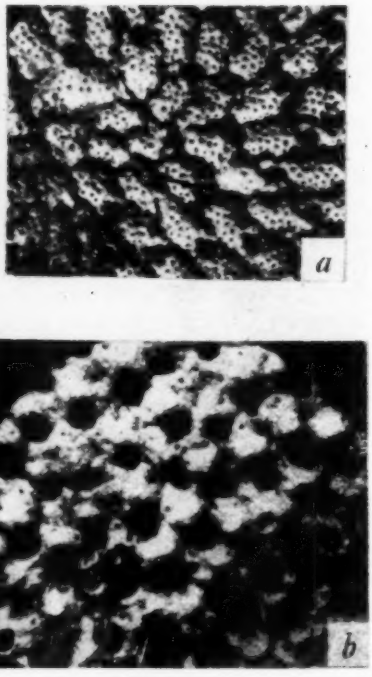

FIG. 13. Photomicrographs of calcined specimens of: *a*, *Smittina bella* (Busk); *b*, *Mucronella peachii* (Johnston).

two to five small pores. Orifice circular, with shallow sinus. Peristome thin collar-like in younger stage (14*c*), thickened with age (14*a*), sinuate or bilobed proximally. Frontal avicularium large, prominent, raised on the mucronate process, with curved end. Ooecia globose (14*b*), distinctly sinuate frontally, smooth. A pair of spines on the distal corner of the peristome. Dorsal vibices (14*e*) salient, limiting elongate quadrate or irregular area. Dorsal avicularia small, elliptic, acute, variable in number. Fenestral perforations rather constant. Operculum (14*f*) subcircular with marginal thickening, mandible (14*g*) triangular, elongate, sometimes with gland, those of dorsal avicularia minute but of the same shape.

SPECIMENS EXAMINED: No. 4009B (Paramushir), No. 4215 (Samani).

Family *CELLEPORIDAE*

42. **Siniopelta costazii** (Audouin), 1826

Zoarium encrusting or discoidal mass. Zooecia decumbent, erect, irregularly crowded. Orifice suborbicular with long sinus, deeply immersed within the peristome. Peristome salient, with erect avicularian processes laterally. Interzooecial avicularia large, scattered, with spatulate mandible. Ooecia decumbent, rounded, broad, with perforated area.

SPECIMENS EXAMINED: No. 1414 (Alaid), No. 1433 (Paramushir), No. 4210 (Samani), No. 4224 (Akkeshi), No. 6288 (Kushiro).

43. **Siniopelta incrassata** (Lamarck), 1856
Fig. 15*a–e*

Zoarium nodulous. Zooecia large, decumbent or erect, piled up in older stage, porous. Zooecial orifice circular with sinus rather longer than wide. Peristome thick, developed; orifice circular, sinuate, with small lateral avicularia on a projection. Ooecia moderate, decumbent, globose, smooth, with perforated frontal. Operculum (15*b*) oval with proximal lip, mandible of dependent avicularium (15*e*) is small, semi-elliptic. Vicarious avicularia occur in two forms, elliptic or circular, with spatulate (15*c*) or semicircular (15*d*) mandibles.

This species is here transferred from *Cellepora*.

SPECIMENS EXAMINED: No. 4020B (Paramushir), No. 4202 (Samani), No. 4231 (Akkeshi), Nos. 6255, 6311 (Kushiro).

Family *MYRIOZOIDAE*

44. **Myriozoum subgracile** d'Orbigny, (1852)
Fig. 15*f–i*

Zoarium erect, tubular, branched, ramose. Zooecia arranged radially around the axis, not distinctly separated. Frontal (15*f*) slightly convex, perforated. Zooecial cavity (15*b*)

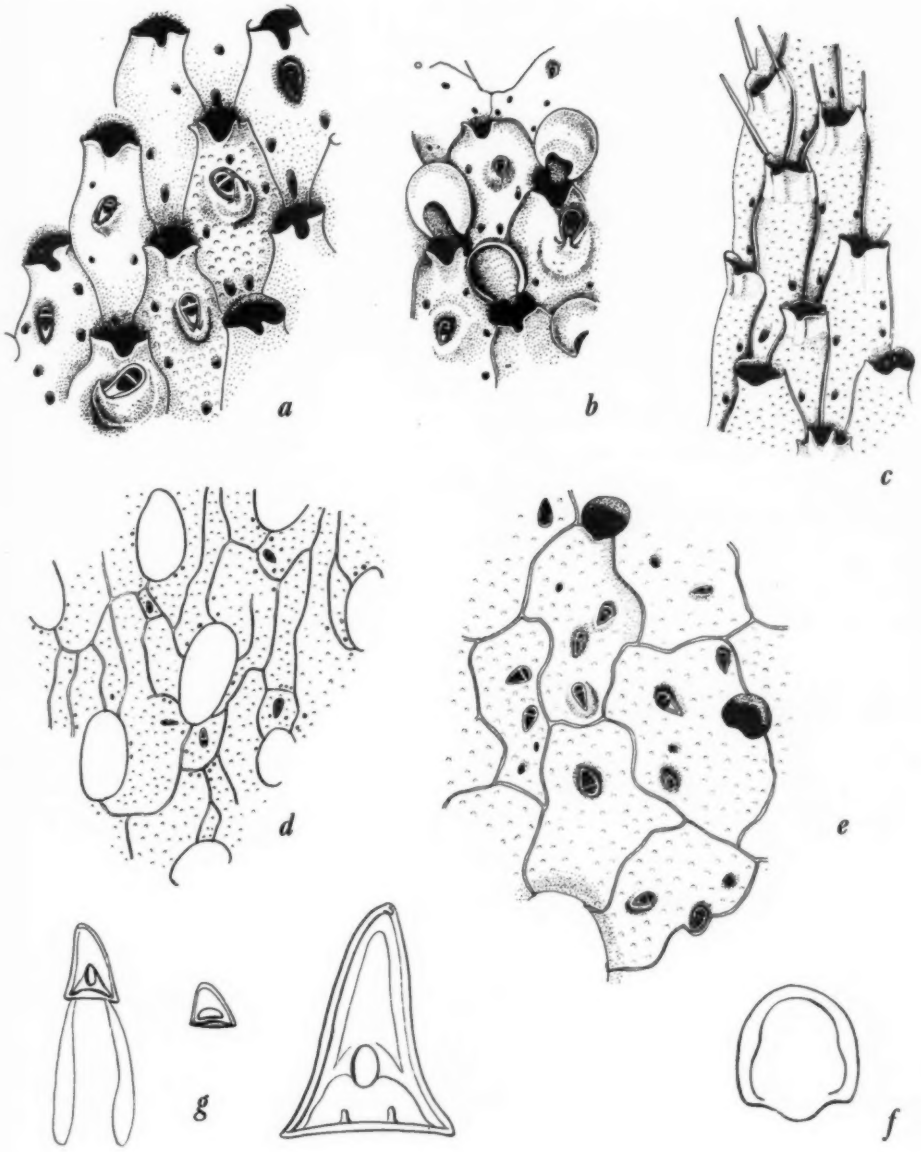

FIG. 14. *Schizoretepora tumescens* (Ortmann): *a*, Frontal view of completed immature zooecia; *b*, fertile zooecia with developing ooecia; *c*, young zooecia near the growing margin; *d*, basal view of a colony; *e*, basal kenozooecia with basal avicularia; *f*, operculum; *g*, small mandible with avicularian glands and mandible of a gigantic frontal avicularium.

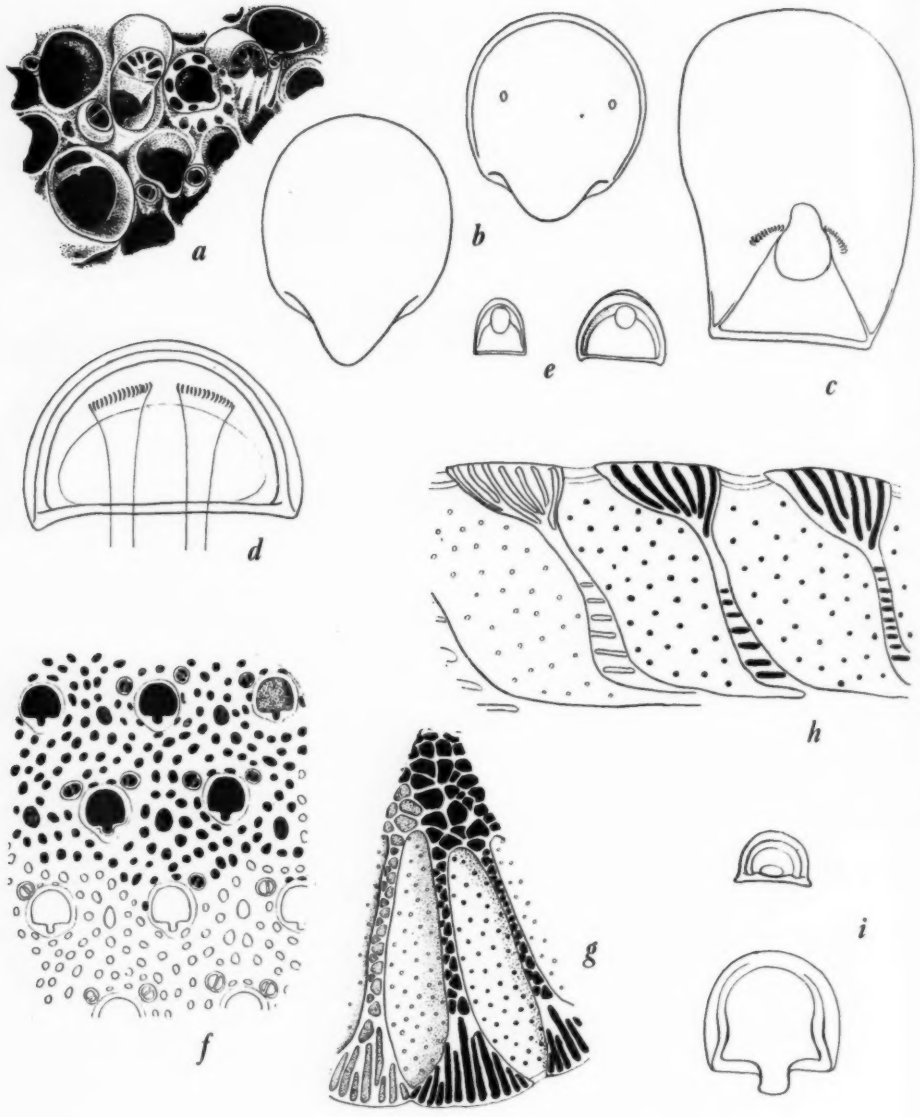

FIG. 15. *a–e*, *Siniopelta incrassata* (Lamarck): *a*, Frontal view of a part of the colony; *b*, opercula; *c*, mandible of a spatulate avicularium; *d*, mandible of a large vicarious avicularium; *e*, mandibles of the frontal avicularia. *f–i*, *Myriozoum subgracile* d'Orbigny: *f*, Frontal view of a branch; *g*, transverse section of a branch; *h*, longitudinal section of a branch showing numerous communication pores piercing the walls; *i*, operculum and mandible.

deep, communicated by pore-tubes (15*g*) in all directions. Orifice semi-elliptic, with narrow sinus, surrounded by low peristome. Ooecium deeply immersed, obscure in frontal view. Avicularia circular or elliptic, with hinge bar on each distal side of peristome, single or paired. Operculum (15*i*) semi-elliptic, with strong submarginal sclerite and proximal lip. Mandible (15*i*) semicircular with fenestra.

SPECIMENS EXAMINED: No. 4021B (Paramushir), No. 4206 (Samani).

45. **Myriozoella planum** (Dawson), 1859

Zoarium encrusting, uni- or multi-lamellar. Zooecia distinct, slightly convex, distinctly or indistinctly separated. Frontal thick, perforated rather coarsely. Orifice semicircular, with sinus and thickened low peristome. A rounded or elliptic avicularium on each side of the orifice, without hinge bar. Operculum semicircular with marginal sclerite and proximal projection. Mandible semi-elliptic with incomplete marginal sclerite. Ooecia immersed, distinct with marginal pores.

SPECIMENS EXAMINED: No. 1423 (Paramushir), No. 1404 (Alaid), No. 6262 (Kushiro).

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A Taxonomic Revision of the Hawaiian Species of the Genus *Sophora* Linnaeus (Family Leguminosae)[1]

ALVIN K. CHOCK[2]

THIS PAPER is based upon a study of the endemic Hawaiian species of the genus *Sophora* L. Previous to the present revision, these endemic taxa were identified as: *Sophora chrysophylla* (Salisb.) Seem., *S. chrysophylla* var. *glabrata* (Gray) Rock, *S. grisea* Degener and Sherff, and the taxon *unifoliata* (Rock, 1919: 44) as a variety of *S. chrysophylla* or as a species (Degener and Sherff, in Sherff, 1951: 24).

In addition to these species, there are three introduced species in the Hawaiian Islands: *S. tomentosa* L., *S. japonica* L., and *S. tetraptera* Forst. The latter two were introduced by Rock (1920: 21). These species are not included in this revision.

The plants of Hawaii are noted for polymorphism. This is thought to be due to the isolation and varied ecological habitats of the Hawaiian Islands, and the high endemism (94.4%) of the flora (Fosberg, 1948: 107). St. John (1946: 379–380) has stated that:

> Some Hawaiian genera contain species that are homogeneous and widespread, occuring unmodified on all or nearly all of the large islands. . . .
>
> There are other Hawaiian species widespread among the larger islands, but which are not homogeneous, having a tendency to vary. These variations are in part recognized as described varieties but in large part are unrecognized, forming a part of the heterogeneous population now included in the species. . . .
>
> Other genera, usually with many species, show a conspicuous segregation into species, usually each species being restricted to a single island or even to a single mountain range or valley on that particular island. . . .
>
> The Hawaiian plants . . . illustrate a progressive series: 1, genera monotypic in Hawaii occurring as invariable wides on all the principal islands; 2, species that are invariable wides, belonging to genera with several Hawaiian species; 3, species that are wides, but showing variability on the various islands; and 4, general [sic] with many Hawaiian species, typically with different, distinct species on each island. These species represent degrees of increasing differentiation and presumably of decreasing age. They show evidences of speciation.

Application of the modern concept of the subspecific entities in a systematic study of the Hawaiian species of *Sophora* has resulted in a revision which clearly reveals the polymorphism of the species, *S. chrysophylla*. This species is usually found in the dry forests from almost sea level to an altitude of 10,000 feet (Rock, 1920: 121). It is also found in two localities in the rain forest at altitudes of 4,000 feet. In the dry forest it is usually the dominant species, and as such is very common on the younger islands of Maui and Hawaii. Its habit may vary from a shrub about 2 meters high to a tree 12 meters high.

The Hawaiians used the wood of this spe-

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cies, which they called mamane (sometimes incorrectly spelled mamani), in making house posts (Brigham, 1908: 84); the runners of holua sleds; and the digging stick, the o'o, which was also used as a club and spear in time of war (Malo, 1951: 21). Ranchers on the island of Hawaii use the wood for fence posts, since mamane wood is very hard and durable (Hillebrand, 1888: 109; Rock, 1913: 189; Hosaka and Ripperton, 1944: 60).

Sophora chrysophylla is valuable in the Hawaiian Islands in the formation of the "dry forest" and in the prevention of soil erosion and excessive dessication of the soil. It is associated with species of *Acacia*, *Diospyros*, *Dodonaea*, and *Myoporum* on the island of Hawaii (Webster, 1951: 52), where it is most abundant. The seeds of mamane retain their viability for a long period of time and this property should prove useful in reforestation (Akamine, 1951: 45).

Acknowledgements

Dr. Harold St. John suggested a revision of this genus and directed my work. Research facilities of the Bernice P. Bishop Museum were made available by Miss Marie Neal. Other institutions (see Abbreviations), including the University of Michigan, graciously provided research facilities or loaned specimens. Dr. M. L. Lohman and Mr. A. R. H. Lamberton of the University of Hawaii assisted in the collections made on the island of Hawaii. Mr. James K. K. Park of the University of Hawaii illustrated the specimens, and Professor Harley H. Bartlett of the University of Michigan supplied the Latin diagnoses.

TAXONOMIC RESUMÉ

The genus *Sophora* was described by Linnaeus in *Genera Plantarum* (1754: 175), based on six species (1753: 373–374): *S. alopecuroides*, *S. tomentosa*, *S. heptaphylla*, *S. genistoides*, *S. tinctoris*, and *S. lupinoides*.

Salisbury (1808: 295–300) established the genus *Edwardsia*, segregating from the genus *Sophora*: *E. microphylla*, from *S. microphylla* and *S. tetraptera*; *E. grandiflora*, from *S. tetraptera*; and described *E. chrysophylla* from a specimen collected by Dr. A. Menzies, botanist on Capt. Vancouver's expedition, presumably from Hualalai, on the island of Hawaii (Wilson, 1920: 162).

Seemann (1865: 66) reduced *Edwardsia* to a section in the genus *Sophora*. Since that time, the Hawaiian species *chrysophylla* has generally been placed in the genus *Sophora*.

Gray (1854: 459) described the variety *glabrata* under *E. chrysophylla*, which was later transferred by Rock (1919: 42–44) to *Sophora*. Hillebrand (1888: 108–109) treats the *Sophora* of Hawaii as one species, without a variety, although he cites Gray as a reference, and notes that the "lower forms are nearly glabrate and bear smaller flowers." Rock (1919: 44) established a new variety, *unifoliata*, from Puu Waawaa, Hawaii.

Until 1951 Degener (in Sherff, 1951: 24) continued to classify mamane under the genus *Edwardsia*, and in 1932 (1932: fam. 169c) raised the var. *unifoliata* to a species (*E. unifoliata* (Rock) Degener). Degener and Sherff (Sherff, 1951: 24) later transferred this species to the genus *Sophora*. In the same paper, *S. grisea* Degener and Sherff was described from collections made by Degener and Greenwell on the island of Oahu.

RELATIONSHIPS OF THE GENUS

The genus *Sophora* consists of more than 25 species, distributed over the warmer regions of both hemispheres, which are found in Asia, South America, the southwest United States, New Zealand, the islands of the South Pacific Ocean, and Hawaii (Rock, 1913: 187).

Our species is a member of the section *Edwardsia*, which is characterized by the four-winged pods, and it is related to *S. tetraptera* Forst. of New Zealand, *S. macrocarpa* Sm. and *S. microphylla* Sol. in Ait. of Peru and Chile, *S. denudata* Bory of Réunion, *S. mollis* Grah. and *S. interrupta* Bedd. of India. *Sophora* is placed in the subfamily *Papilionatae*, and in the tribe *Sophoreae*.

TAXONOMICALLY USEFUL CHARACTERS

S. chrysophylla is a polymorphic species comparable to *Myoporum sandwicense* Gray, which has been treated by Webster (1951). It has been extremely difficult to find morphological characters which do not vary among the plants in a given area; even among the various taxa proposed in this revision, there are both similar and dissimilar characters among the individuals of each taxon. After study, it seemed that a valuable character might be the shape (ovate, obovate, circular, and elliptic) of the standard, which is more or less the same for each plant of the various populations. This is used to define the subspecies.

The shape of the apex and base of the standard, wing, and keel petals; the margin of the wing and keel petals; and the shape and pubescence of the leaflets are used to define the variety, subvariety, and form.

Except in two subvarieties (*ovatifoliolata* and *grisea*), the characteristic leaflet shape is oblong-obovate. The pubescence is strigose, and ranges from abundant to none, and from golden brown to silver. The upper surface ranges from being abundantly pubescent to glabrate. The lower surface is more pubescent than the upper surface.

The calyx tube is usually goblet shaped, and the lobing of the tube may vary, as well as the degree of the parting of the calyx teeth.

The size of the fruit and the width of the wings may vary greatly. Although certain taxa may be characteristically narrow or wide winged, both of these, as well as intergrading widths, may be found on the same plant. Seed color has been found to be an unreliable character, although all of the seeds of a certain taxon may have the same color. It has been found that a fungus infects the seed coat and produces fruiting structures and mycelia which cause changes in the coloration of the seed coat, especially around the hilum, where a gray-black discoloration may appear, which is surrounded by the characteristic yellow-brown color of most mamane seeds. Seeds in one collection (Chock, *et al.*, 594) ranged from yellow, to brown, to red, to gray-black.

These characters are somewhat useful in the classification of the subspecific taxa of *S. chrysophylla*. Abundant flowering material is necessary to determine the different taxa because of the variations that occur within that taxon.

DISTRIBUTION

Collections have been made from the major islands of the Hawaiian group, excepting Kahoolawe and Niihau. However, this species may have occurred on these islands before the dry forest was wiped out by introduced fauna and flora, and erosion.

On the island of Kauai, it is found in the forests of Kokee Territorial Park, at elevations of 3,600 to 4,000 feet. On the island of Oahu, it has been reported or collected from the lee and windward sides of the Waianae Mountains.

On the island of Maui, it is very common on the slopes and in the crater of Haleakala, from 5,000 to 10,000 feet; collections have also been made from the leeward slopes at lower altitudes (1,500 feet). Along the windward slopes, in the rain forest east of Olinda, there is a small population of mamane (4,000 feet). In Olowalu Valley on West Maui, Forbes collected a specimen, the leaflets of which are much smaller than any other known. This material is sterile, however, and has not been rediscovered.

Forbes made a collection from the island of Molokai with a note on the specimen sheet that it was "very rare" on Puu Kolekole. Forbes' collections from Olowalu, Maui, and Puu Kolekole, Molokai, were not included in this revision. On the island of Lanai, Rock (1913: 189) thought that the mamane was planted by man, although this could not be established. G. C. Munro (1954: personal correspondence), a long-time resident of Lanai, however, is of the opinion that it is native to that island.

On the island of Hawaii, it is very common, being one of the dominant endemic species. It is found as such along the slopes of Mauna Loa and Mauna Kea; in the lower forests of the Kau District; and from almost sea level near Puu Waawaa to the slopes of Hualalai. It has also been reported at lower elevations near Milolii by E. Y. Hosaka. Rock (1913: 23) considered this species as the main element in the forest above 3,700 feet. Ripperton and Hosaka (1942: 14) considered it as the dominant species in the "forest formation" from 5,000 feet to the timber line at 10,000 feet, and in the "parkland formation" (zones E_1 and E_2).

The lowest subspecific taxa proposed in this revision are restricted to definite localities on an island. In some localities, however, several taxa may be present.

ABBREVIATIONS

The majority of the specimens which were examined and cited are deposited in the herbarium of Bernice P. Bishop Museum (BISH) in Honolulu, Hawaii. Specimens deposited elsewhere are indicated by the use of the following abbreviations (Lanjouw and Stafleu, 1954):

BM—British Museum of Natural History; F—Chicago Natural History Museum; GH—Gray Herbarium of Harvard University; NY—New York Botanical Garden; US—U. S. National Museum, Smithsonian Institution.

The completeness of the specimens cited is indicated by the following abbreviations: bd.—bud; lv.—leaves; fl.—flower; fr.—fruit; st.—stem; wood—wood specimen collected by A. R. H. Lamberton.

SYSTEMATIC TREATMENT

Genus SOPHORA Linnaeus

Sophora Linnaeus, Species Plantarum, 373, 1753; Genera Plantarum, 175, 1754.
Edwardsia Salisbury, Linn. Soc., Trans. 9: 296–300, 1808.

Shrub to tree; leaves usually pinnate; leaflets usually small and numerous; flowers in simple, terminal racemes or several forming a terminal panicle; calyx cupshaped, with short teeth; corolla yellow, white, rarely purple; standard obovate, elliptic, ovate or orbicular, often shorter than the keel, rarely longer; wing usually oblong, shorter than the keel; stamens free or rarely connected at the base in a ring, with dorsifixed anthers; ovary with many ovules; pod cylindrical to somewhat flattened, often constricted between the seeds, often four-winged (in the section *Edwardsia*), fleshy or woody, usually indehiscent; seeds ovoid or globose.

TYPE SPECIES: *Sophora tomentosa* L. has been chosen as the lectotype of the genus (Camp, *et al.*, 1947: 117).

Section EDWARDSIA (Salisbury) Seemann

Edwardsia Salisbury, Linn. Soc., Trans. 9: 296–300, 1808 (as a genus).
Edwardsia (Salisb.) Seem., Flora Vitiensis, 66, 1865 (as a section).

Fruit constricted between the seeds, with four longitudinal wings on the pod. Leaves usually pinnate, without stipules.

1. **Sophora chrysophylla** (Salisb.) Seem., Flora Vitiensis, 66, 1865

Edwardsia chrysophylla Salisb., Linn. Soc., Trans. 9: 299; tab. 26, fig. 1, 1808.

Shrub to tree, 2–12 meters high, diameter 2–9 dm.; branches longitudinally ridged, the younger branches brown, with abundant golden brown strigose pubescence, becoming gray-black, and silver and glabrate, the older branches glabrous, the ridges not as deep as on the younger branches; leaves alternate, usually pinnate, rarely unifoliolate, bifoliolate, or trifoliolate; leaflets usually opposite and usually oblong-obovate, sometimes broadly elliptic to oblong to oblong-ovate, 3–23 mm. broad, 7–50 mm. long, the apex obtuse to retuse, the base cuneate, the lower surface

usually abundant golden brown strigose, becoming silver, the upper surface glabrate; petiolule 0.5–2 mm. long; rachis-petiole length up to 17 cm., moderately to deeply channeled along the rachis; flowers in terminal racemes or panicles; pedicels 6–30 mm. long; calyx tube goblet-shaped, five lobed, 5–19 mm. broad, 4–12 mm. high; corolla yellow, glabrous; the standard ovate, obovate, circular, or elliptic, the apex obtuse to retuse, the base obtuse to cuneate, 8–20 mm. broad, 11.5–20 mm. long, reflexed when mature, the claw 3–8 mm. long; the petals of the wings oblong-lanceolate to oblong to elliptic, the apex acute to obtuse to truncate, the base asymmetrical or symmetrical, margin entire or irregularly indented, 3–9.5 mm. broad, 12.5–28 mm. long, the claw 3–5.5 mm. long; the petals of the keel elliptic to oblong to ovate to lanceolate, the apex obtuse to acute, the base asymmetrical or symmetrical, the margin entire or irregularly indented, 3.5–12 mm. broad, 14–25 mm. long, the claw 2–6 mm. long; stamens 10, the anthers golden brown, dorsifixed; pistil recurved, abundantly covered with golden brown hairs, with a small terminal stigma; pods 2–16 cm. long, 5–18 mm. broad, including the wings, which are 1–7 mm. wide, tan, but often with a fungus giving the mature fruits a black appearance, abundant to sparse golden brown strigose, becoming silver and glabrate, constricted between the seeds, with four longitudinal wings; seeds oblong-ovoid, ovoid or globose, moderately compressed, golden brown to orange to gray-black, 3–6 mm. wide, 4.5–8 mm. long, 2–4.5 mm. thick.

KEY TO THE SUBSPECIES OF *S. chrysophylla*

A. Standard obovate or ovate . . . . . B
A. Standard circular or elliptic C

B. Standard obovate. (2). ssp. **chrysophylla**
B. Standard ovate . . . . . (8). ssp. **glabrata**

C. Standard circular . . . (27). ssp. **circularis**
C. Standard elliptic . . . (30). ssp. **unifoliata**

2. **Sophora chrysophylla** ssp. **chrysophylla**
Figs. 1*d*, 5

Sophora chrysophylla (Salisb.) Seem., Flora Vitiensis, 66, 1865.

Edwardsia chrysophylla Salisb., Linn. Soc., Trans. 9: 299; tab. 26, fig. 1, 1808.

Tree, 4–8.3 meters high; leaves pinnate; leaflets oblong-obovate, 5–17 mm. broad, 10–34 mm. long; rachis-petiole up to 12 cm. long; pedicels 8–23 mm. long; calyx tube 5–13 mm. broad, 5–12 mm. high; the standard obovate, the base cuneate; the petals of the wing 6–9 mm. broad, 16–28 mm. long, the

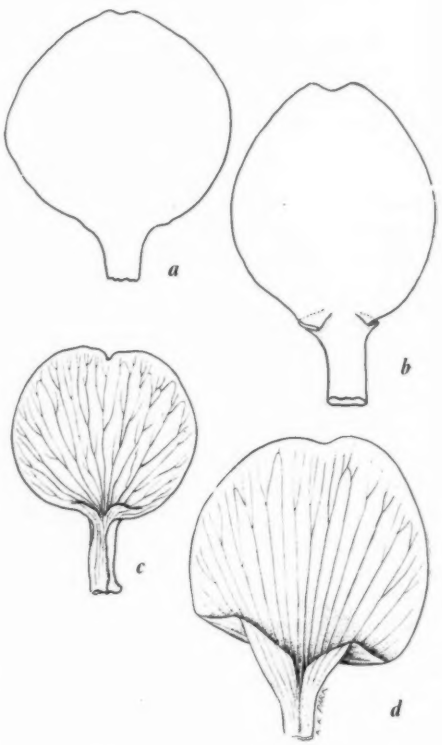

FIG. 1. Standard, × 2: *a*, ssp. *glabrata*, Chock et al. 577; *b*, ssp. *unifoliata*, Degener et al. 19, 327; *c*, ssp. *circularis*, Chock et al. 749; *d*, ssp. *chrysophylla*, Chock et al. 575.

base truncate, but sometimes truncate on one side and cuneate or sagittate on the other side; the petals of the keel 3.5–10 mm. broad, 16.5–23 mm. long; pods 3.1–13 cm. long, including the beak, which is 4–28 mm., 8–15 mm. wide, including the wings, which are 1–4 mm., 1–8 seeded; seeds golden brown to brown to gray-black.

KEY TO SUBSPECIES *chrysophylla*

A. Width of standard under 10 mm., oblong-obovate . . . . . 7. var. **makuaensis**
A. Width of standard over 10 mm., broad obovate . . . . . B. (3. var. **chrysophylla**)

B. Rachis-petiole length always under 6.5 cm.; pedicels 15–23 mm. long . . . . . 5. f. **haleakalaensis**
B. Rachis-petiole length always over 6.5 cm.; pedicels 8–16 mm. long C

C. Margin of keel irregularly indented, the apex obtuse . . . . . 6. f. **obovata**
C. Margin of keel entire, the apex acute . . . . . 4. f. **chrysophylla**

3. **Sophora chrysophylla** ssp. **chrysophylla** var. **chrysophylla**

Sophora chrysophylla (Salisb.) Seem., Flora Vitiensis, 66, 1865.
Edwardsia chrysophylla Salisb., Linn. Soc., Trans. 9: 299; tab. 26, fig. 1, 1808.

The standard obovate, the apex retuse, 16–18 mm. broad, 11.5–18 mm. long.

4. **Sophora chrysophylla** ssp. **chrysophylla** var. **chrysophylla** f. **chrysophylla**
Figs. 1*d*, 2*f*, 3*f*, 4, 5

Sophora chrysophylla (Salisb.) Seem., Flora Vitiensis, 66, 1865.
Edwardsia chrysophylla Salisb., Linn. Soc., Trans. 9: 299; tab. 26, fig. 1, 1808.

Pedicels 10–15 mm. long; calyx tube 10–13 mm. broad, 7–8 mm. high; the petals of the wing elliptic, the apex obtuse, the base truncate, 9 mm. broad, 16 mm. long; the petals of the keel elliptic, the base truncate on one side and sagittate on the other side, the apex acute; seeds brown.

SPECIMEN TYPICUM: "Insulis Sandwich, legit *A. Menzies.*" (BM—examined by R. S. Cowan of the New York Botanical Garden).

SPECIMENS EXAMINED: **Hawaii**, Hualalai—just below summit, west slope, above Puu Laalaau, about 7,500 feet, June 19, 1934,

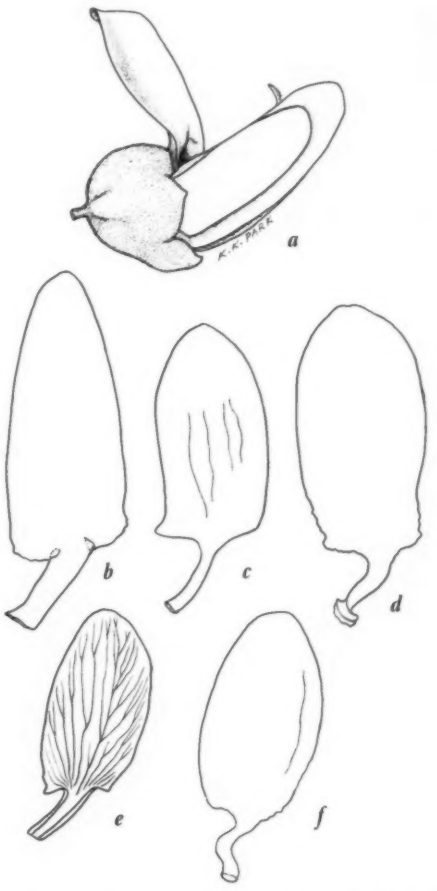

FIG. 2. *a*, Flower, × 2: f. *maunakeaensis*, Chock et al. 577. *b–f*, Keel petals, × 2: *b*, f. *olindaensis*, Chock et al. 286; *c*, var. *kauensis*, Chock et al. 749; *d*, var. *circularis*, Chock et al. 612; *e*, f. *obtusa*, Chock et al. 584; *f*, f. *chrysophylla*, Neal (June 19, 1934).

Marie Neal (st. lv. bd. fl. fr.); slope, 7,000 feet, June 9, 1909, *Rock* (st. lv. bd. fl.); near summit, June 19, 1911, *Forbes 217H* (BISH, NY) (st. lv. fr.).

5. Sophora chrysophylla ssp. **chrysophylla** var. **chrysophylla** f. **haleakalaensis,** forma nov.

Figs. 4, 5

Rachide cum petiolo quam 6.5 cm. breviori; pedicellis 15–23 mm. longis; vexillo late obovato, 18 mm. lato, 16 mm. longo; petalis carinae oblonge ellipticis, apice retusis, basi uno latere truncatis altero sagittatis.

Rachis-petiole up to 6.5 cm. long; pedicels 15–23 mm. long; calyx tube 5 mm. wide and 12 mm. high; the standard broad obovate, 18 mm. broad, 16 mm. long; the petals of the wing oblong, the apex acute, the base truncate on one side and sagittate on the other side, 7 mm. broad, 17 mm. long; the petals of the keel oblong-elliptic, the apex retuse, the base truncate on one side and sagittate on the other side, 8 mm. broad, 23 mm. long; seeds brown.

TYPE: **Maui**, Haleakala crater, small ravine opposite Ka moa o Pele, August 4, 1938, *Hawaiian Bog Survey 2798* (*Cranwell, Selling, and Skottsberg*) (BISH) (st. lv. bd. fl.).

SPECIMENS EXAMINED: **Maui**, Haleakala—crater, Aug., 1910, *Forbes 289M* (BISH, NY) (st. lv. bd. fr.); 1909, *Brigham, Anderson and Hosmer* (st. lv. fr.); west slope, 8,000 feet, May, 1911, *Rock;* near Koolau gap within crater, June 29, 1927, *Degener 17,948* (NY) (st. lv. bd. fr.); crater, 6,000 to 10,000 feet, Oct. 2–5, 1916, *Hitchcock 14,967* (US) (st. lv. bd. fl.); south side of Red Hill, 8,500 feet, Nov. 24, 1950, *Degener, et al., 21,112* (F) (st. lv. bd. fr.).

This form is so named because it occurs on Haleakala.

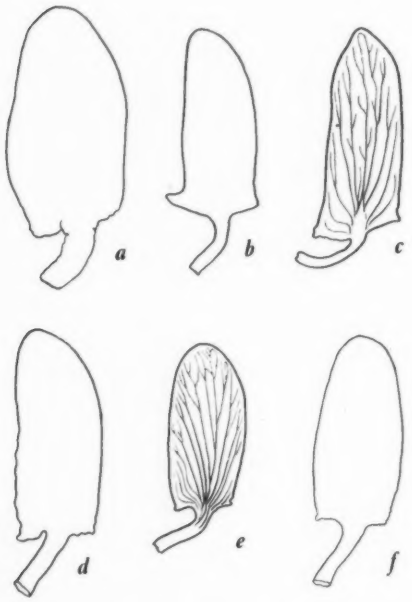

FIG. 3. Wing petals, × 2: *a*, f. *mauiensis*, Chock et al. 283; *b*, var. *kauensis*, Chock et al. 749; *c*, f. *puuwaawaaensis*, Chock et al. 799; *d*, var. *circularis*, Chock et al. 612; *e*, f. *obtusa*, Chock et al. 584; *f*, f. *chrysophylla*, Neal (June 19, 1934).

6. Sophora chrysophylla ssp. **chrysophylla** var. **chrysophylla** f. **obovata,** forma nov.

Figs. 1*d*, 4, 6*a*, *b*

Rhachide cum petiolo quam 10.5 cm. breviori; vexillo obovato, 16 mm. lato, 19 mm. longo; petalis carinae ellipticis, apice obtusis, basi truncatis, margine prope basin irregulariter indentatis.

Rachis-petiole up to 10.5 cm. long; the standard obovate, 16–18 mm. broad, 17–18 mm. long; the petals of the keel elliptic, the apex obtuse, the base truncate, the margin irregularly indented toward the base, 9–10 mm. broad, 19–20 mm. long; seeds golden brown.

TYPE: **Hawaii**, Mauna Kea, south slope, 3.6 miles north of Humuula, Hale Pohaku-Humuula road, Aug. 30, 1952, *Chock, Lohman and Lamberton 575* (BISH) (wood, st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii**, Mauna

Kea, south slope, Aug. 30, 1952, *Chock, et al.*, 579 (st. lv. bd. fl.).

This form is named for the obovate standard petal.

7. **Sophora chrysophylla** ssp. **chrysophylla** var. **makuaensis,** var. nov.

Figs. 4, 6*c*, *d*

Vexillo oblonge obovato, fere truncato, 8 mm. lato, 20 mm. longo.

Rachis-petiole up to 8 cm. long; pedicels 10–20 mm. long; the standard oblong-obovate, the apex obtuse, almost truncate, 8 mm. broad, 20 mm. long; the petals of the wing oblong-lanceolate, the base truncate on one side and cuneate on the other side, 6 mm. broad, 28 mm. long; the petals of the keel ovate-oblong, the apex obtuse, the base truncate on one side and cuneate on the other side, 3.5 mm. broad, 16.5 mm. long; pods 8–9.5 cm. long, the wings 1–2 mm. wide, 6–8 seeded; seeds gray-black.

TYPE: **Oahu**, Waianae Mountains, Makua, Nov. 1929, *Russ* (BISH), 4 sheets (st. lv. bd. fl. fr.).

C. S. Judd (1930(1): 12), former territorial forester, remarks in his report for December, 1929: "I discovered a clump of Mamani [sic] trees (*Sophora chrysophylla*) near the center of Makua Valley. Previously this tree was known only at Ohikilolo. The beautiful yellow blossom were long and slim. . . ."

This variety is so named because it occurs in Makua Valley, Oahu.

8. **Sophora chrysophylla** ssp. **glabrata** (Gray), comb. nov.

Figs. 1*a*, 7, 8

Sophora chrysophylla var. *glabrata* (Gray) Rock, Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry, Bot. Bul. 5: 42–44, 1919.
Edwardsia chrysophylla var. *glabrata* Gray, U. S. Expl. Exped., Botany, Phanerogamia 1: 459–460, 1854.

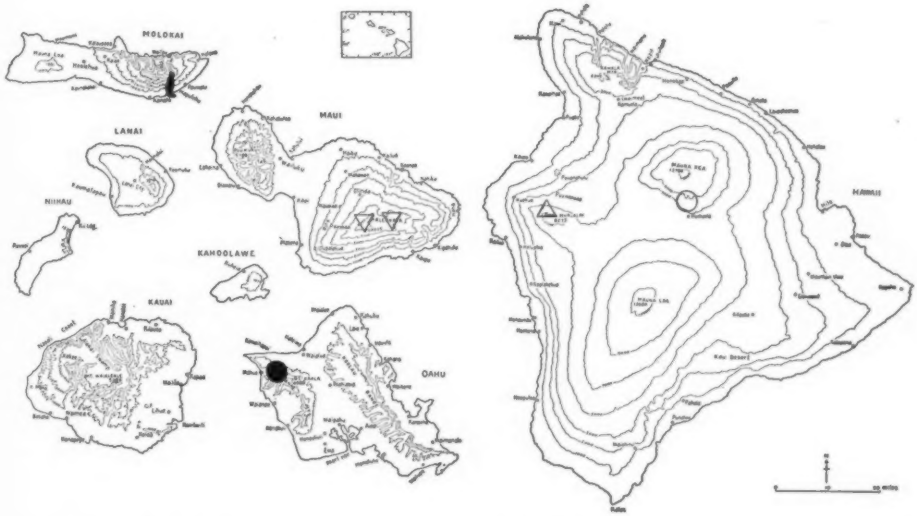

FIG. 4. Map of distribution of *Sophora chrysophylla* ssp. *chrysophylla*. Open erect triangles represent f. *chrysophylla*, open inverted triangles f. *haleakalaensis*, open circle f. *obovata*, solid circle var. *makuaensis*.

Shrub to tree, 2–12 meters high; leaves pinnate, leaflets broadly elliptic to oblong-obovate to oblong to oblong-ovate to oblong-lanceolate; the standard ovate to oblong-ovate, 9–23 mm. broad, 12–18 mm. long; the petals of the wing 3–9.5 mm. broad, 13–21 mm. long, the base usually truncate, the margin sometimes irregularly indented toward the base; the petals of the keel 5–12 mm. broad, 14–22 mm. long, the base usually truncate; pods 2–14.5 cm. long, including the beak, which is 3–20 mm., 5–18 mm. wide, including the wings, which are 0.5–7 mm., 1–8 seeded; seeds golden brown to red-brown to gray-black.

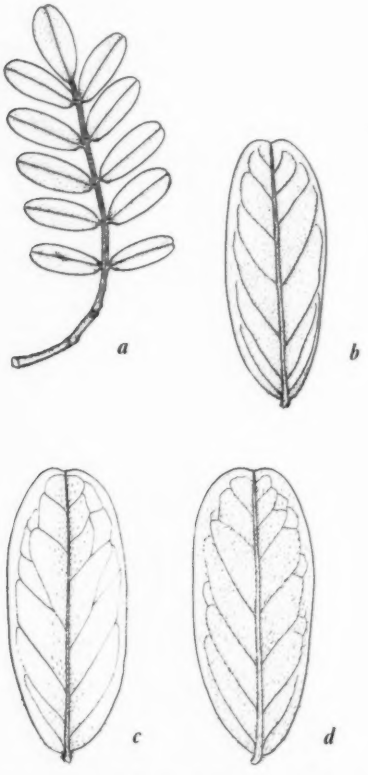

FIG. 5. F. *chrysophylla*, Neal (June 19, 1934): *a*, leaf, upper surface, × 0.5; *b*, 1 aflet (median lateral), lower surface, × 2. Leaflet of f. *halakalaensis*, Rock (May 1911): *c*, upper surface, × 2; *d*, lower surface, × 2.

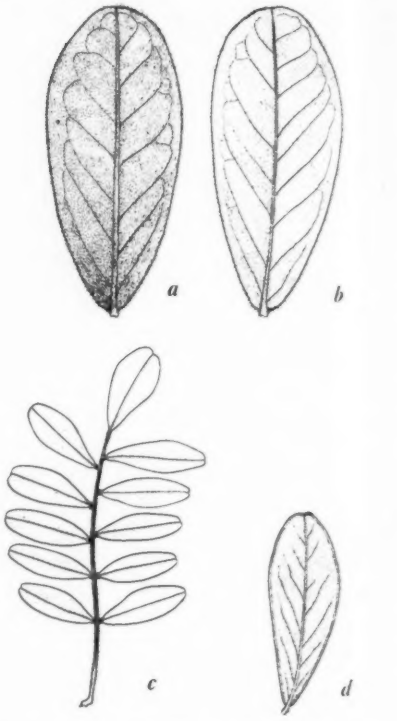

FIG. 6. Leaflet of f. *obovata*, Chock et al. 575: *a*, lower surface, × 2; *b*, upper surface, × 2. Var. *makuaensis*; *c*, leaf, upper surface, × 0.5; *d*, leaflet, lower surface, × 1.

KEY TO SUBSPECIES *glabrata*

A. Leaflets glabrate . . . . . B
A. Leaflets abundantly strigose-pubescent . E

B. Calyx tube 9–11 mm. broad, 4–6 mm. high . . . . . 9. var. **glabrata**
B. Calyx tube 7–8 mm. broad, 6–9 mm. high . . . . . G

C. Standard oblong-ovate, length 1.5 times width . . . . . 10. var. **lanaiensis**
C. Standard ovate, length equal to width, or almost so . . . . . D

D. Calyx tube 7–7.5 mm. broad, 7–8 mm. high; apex of standard obtuse . . . . . 26. f. **parva**

D. Calyx tube 8 mm. broad, 6–9 mm. high; apex of standard retuse.....14. f. **puuwaawaaensis**

E. Apex of standard retuse.....F. (11. var. **ovata**)

E. Apex of standard obtuse.....K. (20. var. **grisea**)

F. Rachis-petiole up to 12 cm. long; largest leaflets 23 mm. broad, 50 mm. long.....G. (12. subvar. **ovata**)

F. Rachis-petiole up to 17 cm. long; largest leaflets 12 mm. broad, 32 mm. long.....I. (16. subvar. **mauiensis**)

G. Margin of wing or keel never irregularly indented; leaflets 3–23 mm. broad, 10–50 mm. long.....13. f. **ovata**

G. Margin of wing or keel always irregularly indented; leaflets 5–15 mm. broad, 10–34 mm. long.....H

H. Margin of wing and keel indented; keel and wing base moderately hastate on one side, the other side truncate; lower surface of leaflets glabrate.....14. f. **puuwaawaaensis**

H. Margin of keel indented, wing margin entire; keel and wing base truncate; lower surface of leaflets abundantly pubescent.....15. f. **maunakeaensis**

I. Base of keel truncate on both sides, symmetrical.....18. f. **lualailuaensis**

I. Base of keel truncate on only one side, asymmetrical; or not truncate.....J

J. Base of keel truncate-oblique, the apex acute.....17. f. **mauiensis**

J. Base of keel obtuse to truncate-oblique, the apex obtuse.....19. f. **olindaensis**

K. Leaflets usually ovate-oblong.....26. subvar. **ovatifoliolata**

K. Leaflets usually obovate-oblong or broadly elliptic.....L

L. Leaflets broadly elliptic, abruptly cuneate at the base.....21. subvar. **grisea**

L. Leaflets oblong to oblong-obovate, the base cuneate...M. (22. subvar. **obtusa**)

M. Base of wing sagittate....23. f. **obtusa**

M. Base of wing not sagittate, but truncate or cuneate, or cuneate on one side and hastate on the other side.....N

N. Base of wing truncate or cuneate, symmetrical.....24. f. **maunaloaensis**

N. Base of wing cuneate on one side and hastate on the other side, asymmetrical.....25. f. **parva**

9. **Sophora chrysophylla** ssp. **glabrata** var. **glabrata** (Gray) Rock, Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry, Bot. Bul. 5: 42–44, 1919.

Fig. 7

Edwardsia chrysophylla var. *B. glabrata* Gray, U. S. Expl. Exped., Botany, Phanerogamia 1: 459–460, 1854.

Rachis-petiole up to 8 cm. long; petiolule 0.5 mm.; leaflets oblong to oblong-obovate, glabrate, 6–10 mm. broad, 13–24 mm. long, upper surface very dark, shiny, lower surface dark, dull; calyx tube 9–11 mm. broad, 4–6 mm. high, pubescent; the standard 13 mm. broad, 9 mm. long, the base obtuse; the petals of the keel oblong, 5 mm. broad, 18 mm. long, the apex acute, the base truncate on one side and cuneate on the other side; fruit 8.5 cm. long, 13 mm. wide, including the wings, which are 3–4 mm.

TYPE: "Sandwich Islands . . . Hawaii, 1,000 feet above Puna," *U. S. Expl. Exped., under Captain Wilkes* (type, US; isotype, G) (st. lv. fl. fr.).

The variety was obviously named for the glabrate condition of the leaflets. The calyx is not glabrate, however, as stated by Gray

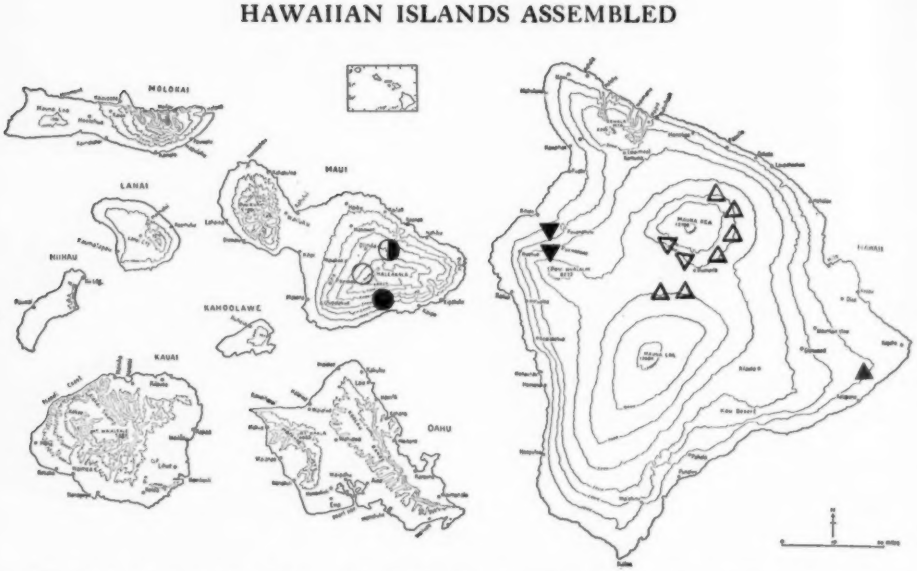

FIG. 7. Map of distribution of *Sophora chrysophylla* ssp. *glabrata*. Solid erect triangle represents var. *glabrata*, open erect triangles f. *ovata*, solid inverted triangles f. *puuwaawaaensis*, open inverted triangles f. *maunakeaensis*, open circle f. *mauiensis*, solid circle f. *lualailuaensis*, half-solid circle f. *olindaensis*.

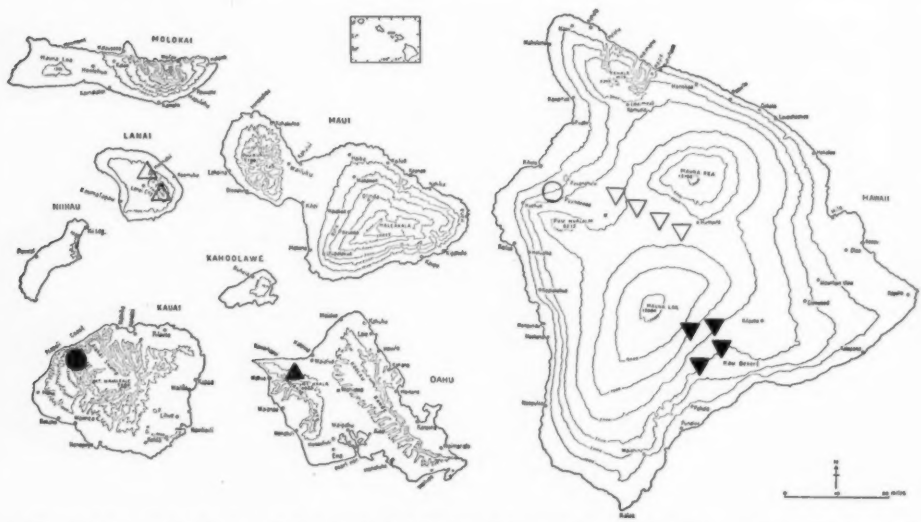

FIG. 8. Map of distribution of *Sophora chrysophylla* ssp. *glabrata*. Open erect triangles represent var. *lanaiensis*, solid erect triangle subvar. *grisea*, open inverted triangles f. *obtusa*, solid inverted triangles f. *maunaloaensis*, open circle f. *parva*, solid circle subvar. *ovatifoliolata*.

(1854: 459). He mentions that "the *flowers* are rather *smaller*."

10. **Sophora chrysophylla** ssp. **glabrata** var. **lanaiensis,** var. nov.
Figs. 8, 9*a*, *b*

S. chrysophylla var. *glabrata* (Gray) Rock, sensu Rock, Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry, Bot. Bul. 5: 42–44, 1919.

Vexillo oblonge ovato, 9 mm. lato, 13 mm. longo.

Leaflets 4–11 mm. broad, 15–30 mm. long; calyx tube 7–8 mm. broad, 7–9 mm. high; the standard oblong-obovate, 9–13 mm. broad, 13–20 mm. long; the petals of the wing oblong-lanceolate, the base hastate, but not symmetrical, the base 5–7 mm. wide, the petals 3–5 mm. broad, 17–21 mm. long; the petals of the keel oblong to oblong-lanceolate, the base obtuse on one side and hastate to cuneate on the other side, 5–8 mm. broad, 19–24 mm. long; the pods 1–5 seeded, the wings 0.5–1.5 mm. wide; seeds gray-black to red-brown.

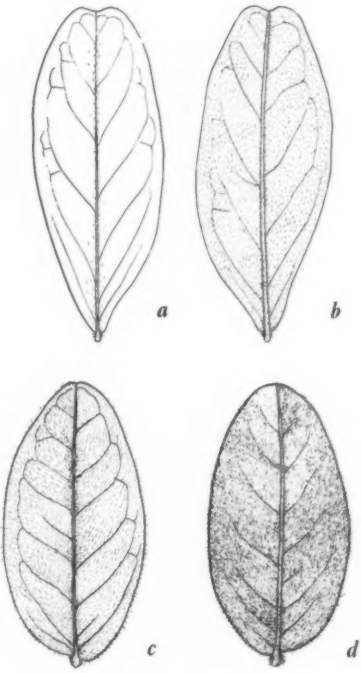

FIG. 9. Leaflet of var. *lanaiensis*, Rock 8012: *a*, upper surface, × 2; *b*, lower surface, × 2. Leaflet of f. *ovata*, Chock et al. 592: *c*, upper surface, × 1.5; *d*, lower surface, × 1.5.

TYPE: **Lanai,** "On the plateau leeward side, near Koele, back of Gibson Homestead, flowering and fruiting July 29, 1910, *Rock no. 8012*" (type: BISH; isotypes: G, NY, US) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Lanai**—mountains of eastern end, June, 1913, *Forbes 234L* (st. lv. bd. fl. fr.); Kaluanui, Apr. 16, 1919, *Munro* (BISH, NY) (st. lv. bd. fl.); ravine in lower plain, Sept. 21, 1916, *A. S. Hitchcock 14,673* (US) (st. lv. bd. fl.).

Hawaiian Islands, no locality—*Mann and Brigham* 352 (BISH, G, NY, US) (fragments: st. lv. bd. fl.).

This variety, which was considered by many botanists to be the same as Gray's var. *glabrata* of Puna, Hawaii, is now separated from that variety and named for its occurrence on the island of Lanai.

11. **Sophora chrysophylla** ssp. **glabrata** var. **ovata,** var. nov.

Foliolis oblonge obovatis vel oblongis vel oblonge ovatis, basi cuneatis; vexillo ovato, apice retuso, basi obtuso.

Leaflets oblong-obovate to oblong to oblong-ovate, the base cuneate; rachis-petiole up to 17 cm. long; calyx tube 8–15 mm. broad, 4–12 mm. high; the standard ovate, the apex retuse, the base obtuse, 13.5–23 mm. broad, 13–18 mm. long; seeds golden brown.

12. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **ovata,** subvar. nov.

Rhachide cum petiolo longitudine quam 12 cm. breviori; foliolis 3–23 mm. latis, 10–50 mm. longis; petalis alarum oblongis vel ellip-

ticis; petalis carinae oblonge ovatis vel ellipticis.

Rachis-petiole length up to 12 cm.; leaflets 3–23 mm. broad, 10–50 mm. long; the petals of the wing oblong or elliptic, the apex obtuse, the margin sometimes irregularly indented toward the base; the petals of the keel oblong-ovate to elliptic, the margin sometimes irregularly indented toward the base.

13. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **ovata** f. **ovata,** forma nov.

Figs. 7, 9*c*, *d*

Petalis alarum ellipticis, apice obtusis, basi truncatis; petalis carinae ovatis, apice obtusis, basi truncatis.

The standard 15–18 mm. broad, 14–16 mm. long; the petals of the wing elliptic, the base truncate, margin entire, 6–9.5 mm. broad, 14–18 mm. long; the petals of the keel oblong-ovate, the apex obtuse, the base truncate, the margin entire.

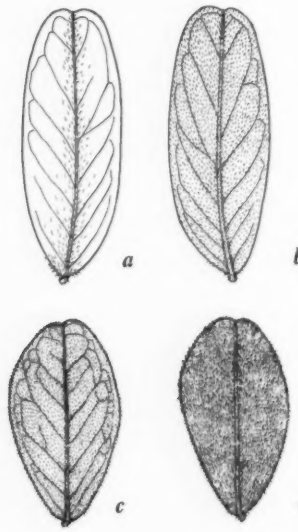

FIG. 10. Leaflet of f. *puuwaawaaensis*, Chock et al. 799: *a*, upper surface, × 2; *b*, lower surface, × 2. Leaflet of f. *maunakeaensis*, Chock et al. 578: *c*, upper surface, × 1; *d*, lower surface, × 1.

TYPE: **Hawaii,** Mauna Kea, southeast slope, 6.9 miles northeast of Humuula, Mauna Kea contour road, 7,000 feet, Aug. 31, 1952, *Chock et al. 592* (BISH) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii,** Mauna Kea, east slope, Mauna Kea contour road, near Laumaia, 6,700–9,000 feet, Aug. 31, 1952—*Chock et al. 594* (st. lv. bd. fr.); *Chock et al. 611* (st. lv. bd. fl. fr.); *Chock et al. 615* (st. lv. fr.); *Chock et al. 618* (st. lv. fr.); *Chock et al. 620* (st. lv. bd. fl. fr.); *Chock et al. 621* (st. lv. bd. fr.); Aug. 18, 1935, *Neal and Hartt 866* (st. lv. bd. fl.). Mauna Loa, north slope, Hilo-Kona road, 8,000 feet, Sept. 3, 1952—*Chock et al. 662* (st. lv. fr.); *Chock et al. 664* (st. lv. fr.); *Chock et al. 667* (st. lv. fr.); *Chock et al. 670* (st. lv. bd. fl. fr.).

This form is named for the ovate standard petal.

14. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **ovata** f. **puuwaawaaensis,** forma nov.

Figs. 3*c*, 7, 10*a*, *b*

Foliolis subtus glabratis; petalis alarum carinaeque irregulariter indentatis, basi modice in latere uno hastatis, altero truncatis.

Leaflets glabrate, 5–14 mm. broad, 12–25 mm. long; calyx tube 8 mm. broad, 6–9 mm. high; the petals of the wing oblong, the base truncate on one side and moderately hastate on the other side, the margin sometimes irregularly indented toward the base, 4–5 mm. broad, 13–15 mm. long; the petals of the keel oblong-elliptic, the margin irregularly indented toward the base, 7–8 mm. broad, 15 mm. long; pods 3.8–12 cm. long, 9–13 mm. wide; seeds golden brown.

TYPE: **Hawaii,** North Kona District, Mamalahoa highway, 4.1 miles northeast of Puu Waawaa Ranch road, 2,300 feet, Sept. 10, 1952, *Chock et al. 799* (BISH) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii,** Puu Waawaa Ranch, 1,800 to 2,300 feet, Sept. 8, 1952—*Chock et al. 783* (st. lv. bd. fl.); *Chock et al.*

784 (st. lv. fr.); *Chock et al. 785* (st. lv. bd. fr.); *Chock et al. 788* (st. lv. bd. fr.); Sept. 10, 1952, *Chock et al. 798* (st. lv. bd. fl. fr.); Sept. 7, 1949, *Degener 20,109* (F) (st. lv. bd. fr.); Huehue, Feb. 11, 1952, *Degener 21,818* (F) (st. lv. bd. fl. fr.).

This form is named for its occurrence in the Puu Waawaa region on the island of Hawaii.

15. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **ovata** f. **maunakeaensis,** forma nov.

Figs. 2*a*, 7, 10*c*, *d*

Foliolis subtus dense pubescentibus; petalis alarum integris, basi truncatis; petalis carinae irregulariter indentatis, basi truncatis.

Leaflets abundantly pubescent on the lower surface, 5–15 mm. broad, 10–34 mm. long; the petals of the wing elliptic, the base truncate, the margin entire, 7–7.5 mm. broad, 14.5–17.5 mm. long; the petals of the keel elliptic, the base truncate, the margin irregularly indented toward the base, 8–8.5 mm. broad, 16–19 mm. long; seeds golden brown.

TYPE: **Hawaii,** Mauna Kea, south slope, 3.1 miles north of Humuula, Humuula-Hale Pohaku road, Aug. 30, 1952, *Chock et al. 578* (BISH) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii,** Mauna Kea, south slope, Humuula-Hale Pohaku road, 8,000–10,000 feet, Aug. 30, 1952—*Chock et al. 580* (st. lv. bd. fl.); near timberline, *Chock et al. 577* (wood, st. lv. bd. fl. fr.); Sept. 2, 1949, *Degener & Murashige 19,997* (F) (st. lv. bd. fl. fr.); Sept., 1949, *Degener* (F) (st. lv. fl.); Aug. 18, 1949, *Degener 20,236* (F) (st. lv. bd. fl. fr.).

This form is named for its occurrence on the slopes of Mauna Kea on the island of Hawaii.

16. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **mauiensis,** subvar. nov.

Rhachide cum petiolo minus quam 17 cm. longo; foliolis 5–12 mm. latis, 13–32 mm. longis; petalis alarum carinaeque oblonge ellipticis.

Leaflets 5–12 mm. broad, 13–32 mm. long; rachis-petiole up to 17 cm. long; the standard ovate; the petals of the wing oblong-elliptic, the base cuneate on one side and hastate on the other side; the petals of the keel oblong-elliptic, the margin usually irregularly indented toward the base; seeds golden brown.

17. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **mauiensis** f. **mauiensis,** forma nov.

Figs. 3*a*, 7, 11*a*, *b*

Vexillo ovato, 23 mm. lato, 18 mm. longo; petalis carinae basi oblique truncatis, apice acutis.

Rachis-petiole up to 9 cm. long; the petals of the wing 8.5 mm. broad, 18.5 mm. long, the apex obtuse; the petals of the keel 10

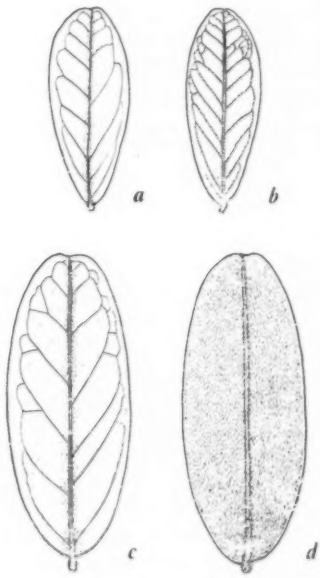

FIG. 11. Leaflet of f. *mauiensis*, Chock et al. 283: *a*, upper surface, × 1; *b*, lower surface, × 1. Leaflet of f. *lualailuaensis*, Forbes 1986M: *c*, upper surface, × 2; *d*, lower surface, × 2.

mm. broad, 20 mm. long, the apex acute, the base truncate-oblique.

TYPE: **Maui,** Haleakala, north-west-west slope, 0.8 miles from 8,000 feet level (road marker), Haleakala road, 8,450 feet altitude, Dec. 24, 1951, *Chock et al. 283* (BISH) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Maui,** Haleakala—between Olinda and Haleakala summit, June 15, 1927, *Degener and Wiebke 2279* (NY, US) (st. lv. fr.); 1,666 M., Feb., 26, 1902, *J. G. Smith* (US) (st. fl.); 8,000 ft., April 1, 1947, *Alexander & Kellogg 5285* (US) (st. lv. bd. fl.).

This form is named for its occurrence on Maui.

18. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **mauiensis** f. **lualailuaensis,** forma nov.

Figs. 7, 11*c*, *d*

Vexillo ovato, 15 mm. lato, 13 mm. longo; petalis carinae basi truncatis apice obtusis.

Rachis-petiole up to 11 cm. long; the standard 15 mm. broad, 13 mm. long; the petals of the wing 7 mm. broad, 15 mm. long, the apex obtuse; the petals of the keel 8 mm. broad, 15 mm. long, the apex obtuse, the base truncate.

TYPE: **Maui,** cone of south side of Haleakala, cone near Lualailua Hills, Kohekamanawa [?], Mar. 17, 1920, *Forbes 1986M* (BISH) (st. lv. bd. fl.).

This form is named for its occurrence near the Lualailua Hills, Maui.

19. **Sophora chrysophylla** ssp. **glabrata** var. **ovata** subvar. **mauiensis** f. **olindaensis,** forma nov.

Figs. 2*b*, 7, 12

Rhachide cum petiolo minus quam 17 cm. longo; petalis carinae oblonge ellipticis, apice obtusis, basi obtusis vel oblique truncatis.

Rachis-petiole up to 17 cm. long; the petals of the wing 8 mm. broad, 20 mm. long, the apex acute, the base truncate; the petals of the keel 10 mm. broad, 22 mm. wide, the apex obtuse, the base obtuse to truncate-oblique.

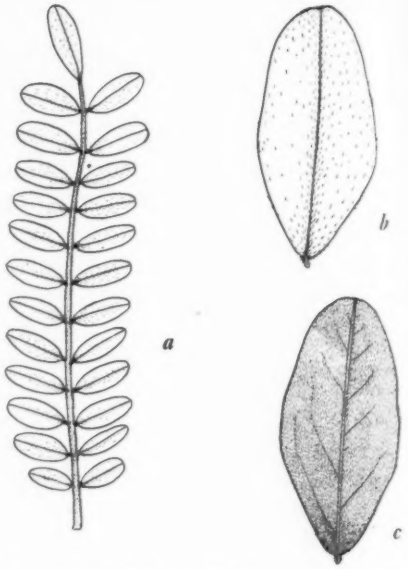

FIG. 12. F. *olindaensis*, Chock et al. 286: *a*, leaf, upper surface, × 0.5; *b*, leaflet, upper surface, × 2; *c*, leaflet, lower surface, × 2.

TYPE: **Maui,** Makawao, Olinda Pipe Line road, 4,600 feet, in wet gulch, tree 10 meters high with few leaves and large number of flowers, Dec. 25, 1951, *Chock et al. 286* (BISH) (st. lv. bd. fl.).

SPECIMENS EXAMINED: Same locality, Dec. 25, 1951, *Chock et al. 311* (st. lv. bd. fl.); same locality, June 27, 1927, *Degener* (NY) (st. lv. bd.).

This form grows in an area where the rainfall is over 200 inches a year, and is named for its occurrence in the Olinda region, Maui.

20. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** (Degener and Sherff), comb. nov.

Sophora grisea Degener and Sherff, in Sherff, Bot. Leaflets, 5: 24–25, 1951.

Leaflets broadly elliptic to oblong-ovate to oblong to oblong-ovate, abundantly pube-

scent, 3–22 mm. broad, 7–40 mm. long; petiolule 0.5–1.5 mm. long; rachis-petiole up to 16.5 cm. long; pedicels 5–25 mm. long; calyx tube 5–10 mm. broad, 6–11 mm. high; the standard ovate to oblong-ovate, the apex and base obtuse, 10.5–17 mm. broad, 12–17 mm. long; the petals of the wing 4.5–8 mm. broad, 13–19 mm. long, the base usually truncate; the petals of the keel 5–12 mm. broad, 14–20 mm. long, the base usually truncate; pods 2–14.5 cm. long, 7–15 mm. wide; seeds gray-black to golden brown.

21. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **grisea** (Degener and Sherff), comb. nov.

Figs. 8, 13*a*, *b*

Sophora grisea Degener and Sherff, in Sherff, Bot. Leaflets 5: 24–25, 1951.

Leaflets usually broadly elliptic, 6–22 mm. broad, 14–40 mm. long; rachis-petiole up to 11 cm. long; calyx tube 9.5 mm. broad, 7 mm. high; the standard oblong-ovate, 10.5–12 mm. broad, 15–17 mm. long; the petals of the wing oblong-lanceolate, 4–5 mm. broad, 14 mm. long; the petals of the keel oblong to oblong-ovate, 5–8 mm. broad, 15–17 mm. long; pods 7 mm. wide, including the wings, which are 1–15 mm.; seeds gray-black.

TYPE: **Oahu,** Waianae Mts., DuPont trail, Oct. 23, 1949, *Degener and Greenwell* (F, type; BISH, fragment of type) (st. lv. fr.).

SPECIMENS EXAMINED: **Oahu**—Waianae Mts., Makaha valley, Feb. 12–19, 1909, *Forbes* (st. lv. fl.); *Remy*, ex. herb. A. Gray (NY) (st. lv. bd. fl.); Dec. 4, 1951, *Degener* (F) (st. lv.); DuPont trail, 2,500 ft., Sept. 9, 1950, *Hatheway, et al., 349* (F) (st. lv. fl.).

This taxon was named by Degener and Sherff in allusion to the seed color.

22. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **obtusa,** subvar. nov.

Foliolis oblongis vel oblonge obovatis, basi cuneatis; vexillo ovato, apice obtuso.

Leaflets oblong-obovate to oblong to oblong-ovate, the base cuneate; the standard ovate, the apex obtuse, 12–15 mm. broad, 12–17 mm. long; the petals of the wing with the apex obtuse; the petals of the keel 6–8 mm. broad, 14–17.5 mm. long; seeds golden brown.

23. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **obtusa** f. **obtusa,** forma nov.

Figs. 2*e*, 3*e*, 8, 13*c*, *d*

Petalis alarum ellipticis, apice obtusis, basi modice sagittatis; petalis carinae oblongis, apice obtusis, basi obtusis in latere uno, in altero modice sagittatis.

Leaflets oblong-obovate, 5–15 mm. broad, 10–34 mm. long; rachis-petiole up to 13 cm. long; the petals of the wing elliptic, the apex obtuse, the base moderately sagittate, 7.5 mm. wide, 13 mm. long; the petals of the keel oblong, the apex obtuse, the base obtuse on one side and moderately sagittate on the other side, 6 mm. broad, 14 mm. long.

TYPE: **Hawaii,** Mauna Kea–Mauna Loa Saddle, Waikii, 10.4 miles west of Pohakuloa, 5,500 feet, Aug. 30, 1952, *Chock, et al., 584* (BISH) (st. lv. bd. fl. fr.).

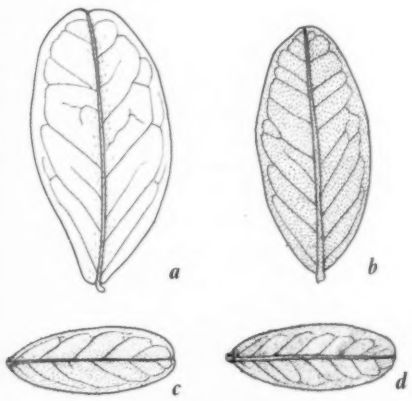

FIG. 13. Leaflet of subvar. *grisea: a*, upper surface, × 1, Degener and Greenwell (October 23, 1949); *b*, lower surface, × 1, Forbes (February 12–19, 1909). Leaflet of f. *obtusa*, Chock et al. 584: *c*, upper surface, × 1; *d*, lower surface, × 1.

SPECIMENS EXAMINED: **Hawaii,** Mauna Kea–Mauna Loa Saddle—Waikii, Aug. 30, 1952, *Chock, et al., 582* (st. lv. bd. fr.); same locality, *Chock, et al., 583* (st. lv. bd. fr.); Pohakuloa, Bd. of Agr. & For. camp, 6,000 feet, Sept. 1, 1952, *Chock, et al., 625* (st. lv. fr.).

This form is named for the obtuse apex of the standard petal.

24. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **obtusa** f. **maunaloaensis,** forma nov.

Figs. 8, 14*a*, *b*

Petalis alarum oblongis, apice obtusis, basi truncatis; petalis carinae oblonge ellipticis, apice acutis, basi subsagittatis.

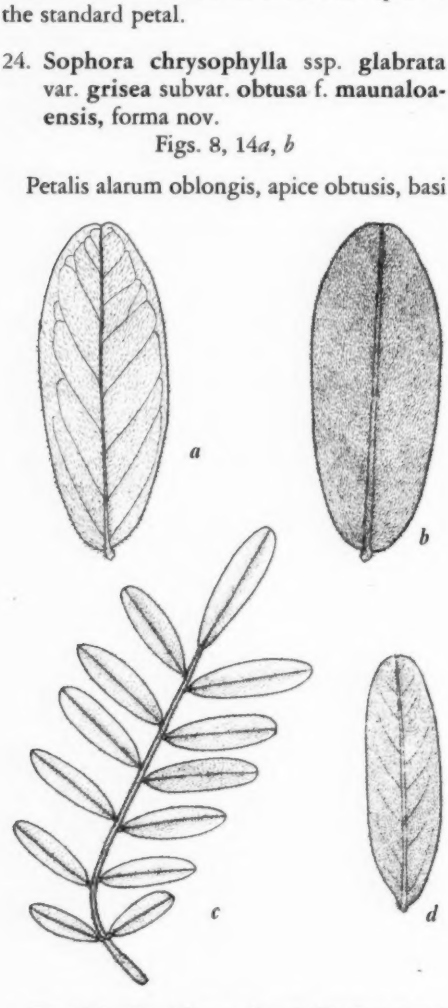

FIG. 14. Leaflet of f. *maunaloaensis*, Chock et al. 726: *a*, upper surface, × 1; *b*, lower surface, × 1. Leaf and leaflet of f. *parva*, Chock et al. 782: *c*, leaf, upper surface, × 1; *d*, leaflet, lower surface, × 2.

Leaflets oblong-obovate, 5–16 mm. broad, 10–41 mm. long; rachis-petiole up to 13 cm. long; the petals of the wing oblong, 7–8 mm. broad, 19 mm. long; the petals of the keel oblong-elliptic, the apex acute, the base subsagittate, 8 mm. broad, 16 mm. long; seeds golden brown.

TYPE: **Hawaii,** Hawaii Natl. Park, Feb., 1952, *Hubbard* (BISH) (st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii,** Mauna Loa, southeast slopes, Hawaii Natl. Park, Mauna Loa–Kilauea section road, Sept. 5, 1952—6,700 feet, *Chock, et al., 726* (st. lv. fr.); same locality, *Chock, et al., 727* (st. lv. fr.); same locality, *Chock, et al., 728* (st. lv. bd. fr.); 4,400 feet, *Chock, et al., 730* (st. lv. bd. fr.); same locality, *Chock, et al., 733* (st. lv. bd. fr.).

Hawaii, Hawaii Natl. Park, Mauna Loa–Kilauea section—in kipuka 8.5 miles along Kau road from Volcano House, July 22, 1926, *Degener 9848* (NY) (st. lv. fl. fr.); Sept., 1908, *Forbes, et al.*, (BISH, NY) (st. lv. fr.); lava "oasis" beyond Bird Park, Dec. 26, 1922, *Degener* (NY) (st. lv. fr.); 7 miles west of Volcano House along Kau road, July 21, 1926, *Degener 9844* (NY) (st. lv. fr.); Kilauea (drawn for *Plants of Hawaii Natl. Park*, plate 47), Aug., 1929, *Degener* (NY) (st. lv. bd. fr.); on trail to rest house (Mauna Loa), 7,000 ft., Sept. 13, 1916, *A. S. Hitchcock 14,634* (US) (st. lv. bd. fl.); east of Kilauea-iki, July 17, 1926, *Degener 9845* (US) (st. lv. bd.); Bird Park, 4,000 ft., Dec. 22, 1931, *St. John, et al., 11,261* (BISH, US) (st. lv. bd. fl.).

This form is named for its occurrence on the eastern slopes of Mauna Loa in Hawaii National Park.

25. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **obtusa** f. **parva,** forma nov.

Figs. 8, 14*c*, *d*

Foliolis glabratis; petalis alarum oblongis, apice obtusis, basi in latere uno cuneatis, in

altero modice hastatis; petalis carinae oblongis, apice acutis, basi oblique truncatis. Leaflets glabrate, 3–11 mm. broad, 7–20 mm. long; rachis-petiole length up to 7 cm.; the petals of the wing oblong, the apex obtuse, the base truncate or cuneate on one side and moderately hastate on the other side, 4.5–5 mm. broad, 14 mm. long; the petals of the keel oblong, the apex acute, the base truncate-oblique, 6.5–7 mm. broad, 16.5–17.5 mm. long; pods 2–4 cm. long, the wings 1.5–2.5 mm. wide, 1–4 seeded, usually 2 seeded.

TYPE: **Hawaii,** North Kona District, Puu Waawaa Ranch, junction of Mamalahoa highway and Puu Waawaa ranch road, 2,300 ft., Sept. 8, 1952, *Chock, et al., 782* (BISH) (st. lv. bd. fl.).

SPECIMENS EXAMINED: **Hawaii,** Puu Waawaa Ranch—2,300 ft., Sept. 8, 1952, *Chock, et. al., 775* (st. lv. bd. fr.); 3 miles west of Puu Waawaa, 3,000 ft., June 21–23, 1948, *Wilbur and Webster 1887* (st. lv. fl.).

This form is named in allusion to its small size in habit, the narrow wings of the pods, and the small leaflets.

26. **Sophora chrysophylla** ssp. **glabrata** var. **grisea** subvar. **ovatifoliolata,** subvar. nov.

Figs. 8, 15*a*, *b*

Foliolis oblonge ovatis.

Leaflets ovate-oblong, the few larger leaflets being oblong to obovate-oblong, 6–17 mm. broad, 15–38 mm. long; calyx tube 9.5 mm. broad, 11 mm. high; the standard ovate, 17 mm. broad, 17 mm. long; the petals of the wing ovate-oblong, 8 mm. broad, 19 mm. long; the petals of the keel elliptic, the apex obtuse, 12 mm. broad, 20 mm. long; the wings of the pods under 2 mm. wide; seeds orange-brown.

TYPE: **Kauai,** Na Pali–Kona Forest Reserve, Kokee Terr. Park, 4,000 feet, near Kalalau Lookout, in rain forest, specimen from 2–3 trees (7 m. x 5 cm.), Dec. 24, 1952, *St. John, et al., 24,879* (BISH) (st. lv. bd. fl. fr.).

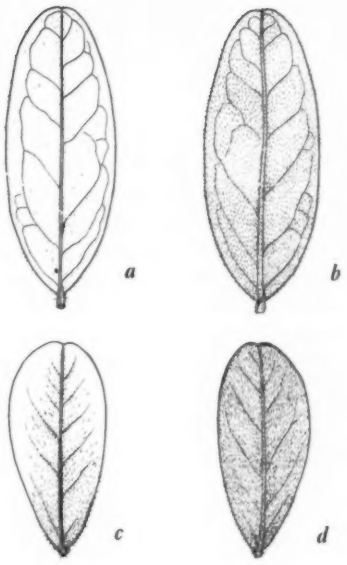

FIG. 15. Leaflet of subvar. *ovatifoliolata*, St. John et al. 24,879: *a*, upper surface, × 1.5; *b*, lower surface, × 1.5. Leaflet of var. *circularis*, Chock et al. 612: *c*, upper surface, × 1; *d*, lower surface, × 1.

SPECIMENS EXAMINED: **Kauai,** Kokee Terr. Park—same locality as type, Nov., 1951, *Souza* (st. lv. bd. fr.); same locality, July 4, 1926, *Degener 9847* (NY) (st. lv.); same locality, *Degener and Greenwell, 21,513* (F) (lv. fl. bd.); Kaunuohua ridge, northeast of Pohakuwaawaa, Jan. 12, 1952, *Degener and Greenwell 21,745* (F) (st. lv. bd. fl.); Kopiwai trail, Jan. 11, 1952, *Degener and Greenwell 21,742* (F) (st. lv. bd. fl.); Nualolo trail, 2,000–3,750 feet, Dec. 28, 1930, *St. John, et al., 10,810* (st. lv. bd. fl.); Waimea Drainage Basin, west side, Nualolo trail, July 3 to Aug. 18, 1917, *Forbes 965K* (st. lv.); road to Halemanu hill, 3,700 feet, Sept. 7, 1953, *Chock 1194* (st. lv. fr.); same locality, *Chock 1196* (st. lv.).

A large number of seedlings were observed near Halemanu hill, with several scrubby trees 2 meters high. This subvariety is named in allusion to the ovate leaflets.

27. **Sophora chrysophylla** ssp. **circularis,** ssp. nov.

Figs. 1, 19

Vexillo circulari.

Shrub to tree, 4–5 meters high; leaflets oblong-obovate, 6–14 mm. broad, 13–37 mm. long, abundantly pubescent to glabrate; petiolule 1–1.5 mm.; rachis-petiole up to 12 cm. long; pedicels 6–13 mm. long; the standard circular, the apex retuse, the base obtuse, the breadth and length the same, 13–18 mm.; the petals of the wing with the apex obtuse, the base hastate on one side and truncate on the other side; pods 4–11 cm. long, 7–17 mm. wide, 1–7 seeded; seeds orange-brown or golden brown.

KEY TO SUBSPECIES *circularis*

A. Rachis-petiole maximum length 12 cm.; pubescence on the lower surface of the leaflets abundant; wing petals elliptic . . . . . 28. var. **circularis**

A. Rachis-petiole maximum length 7 cm.; lower surface of leaflets glabrate; wing petals oblong-lanceolate . . . . . 29. var. **kauensis**

28. **Sophora chrysophylla** ssp. **circularis** var. **circularis,** var. nov.

Figs. 2*d*, 3*d*, 15*c*, *d*, 19

Rhachide cum petiolo minus quam 12 cm. longo; foliolis subtus dense pubescentibus; petalis alarum ellipticis.

The lower surface of the leaflets abundant strigose-pubescent; rachis-petiole up to 12 cm. long; calyx tube 12 mm. broad, 10 mm. high; the petals of the keel elliptic, the apex obtuse, the base cuneate on one side and truncate on the other side, the margin irregularly indented toward the base, 9 mm. broad, 19 mm. long; pods 3 seeded, the wings 3 mm. wide; seeds golden brown, 5 mm. wide, 7–8 mm. long, 4 mm. thick.

TYPE: **Hawaii,** Mauna Kea, east slope, 15.9 miles northeast of Humuula, Mauna Kea contour road, 6,700 feet, Aug. 31, 1952, *Chock, et al., 612* (BISH) (st. lv. bd. fl. fr.).

This variety is named for the circular petal.

29. **Sophora chrysophylla** ssp. **circularis** var. **kauensis,** var. nov.

Figs. 1*c*, 2*c*, 3*b*, 16*a*, *b*, 19

Rhachide cum petiolo minus quam 7 cm. longo; foliolis subtus glabratis; petalis alarum oblonge lanceolatis.

The lower surface of the leaflets glabrate; rachis-petiole up to 7 cm. long; calyx tube 8 mm. broad, 8 mm. high; the petals of the wing oblong-lanceolate, 5.5 mm. broad, 14 mm. long; the petals of the keel oblong-elliptic, the apex acute, the base cuneate on one side and hastate on the other side, 8.5 mm. broad, 17 mm. long; pods 1–7 seeded;

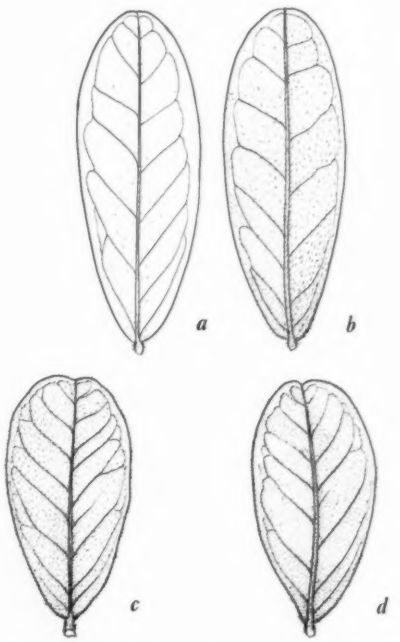

FIG. 16. Leaflet of var. *kauensis*, Chock et al. 749: *a*, upper surface, × 2; *b*, lower surface, × 2. Unifoliolate leaf of var. *unifoliata*, Rock 13,011: *c*, upper surface, × 1; *d*, lower surface, × 1.

seeds orange-brown, 3–4 mm. wide, 5 mm. long, 2.5–3.5 mm. thick.

TYPE: **Hawaii,** Kau District, Mamalahoa highway, 4.5 miles west of Kahuku Ranch entrance, 1,900 feet, Sept. 6, 1952, *Chock, et al., 749* (BISH) (wood, st. lv. bd. fl. fr.).

SPECIMENS EXAMINED: **Hawaii,** near 1907 lava flow, Feb. 14, 1952, *Degener 21,820* (F) (st. lv. bd. fl. fr.).

This variety is named for its occurrence in the Kau District on the island of Hawaii.

30. **Sophora chrysophylla** ssp. **unifoliata** (Rock), comb. nov.

Figs. 1*b*, 19

Sophora chrysophylla var. *unifoliata* Rock, Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry, Bot. Bul. 5: 44, 1919.

Edwardsia unifoliata (Rock) Degener, Flora Hawaiiensis, family 169c, 1932.

Sophora unifoliata (Rock) Degener and Sherff, in Sherff, Bot. Leaflets 5: 24, 1951.

Shrub to tree, 3.5–8 meters high, leaves alternate, unifoliolate to pinnate; leaflets oblong-obovate, 6–19 mm. broad, 12–49 mm. long; petiolule 1 mm.; rachis-petiole (of pinnate leaves) up to 8.5 cm. long; pedicels 5–18 mm.; calyx tube 7–10 mm. broad, 4–8 mm. high; the standard elliptic, 10–16 mm. broad, 13–20 mm. long; the petals of the wing oblong-lanceolate, the apex obtuse, the base hastate, 3–5 mm. broad, 12.5–21 mm. long; the petals of the keel oblong to oblong-lanceolate, 3–6.5 mm. broad, 8–25 mm. long; no fruits on specimens.

KEY TO SUBSPECIES *unifoliata*

A. Leaves typically unifoliolate to trifoliolate, petiole 2 mm.; margin of keel sometimes irregularly indented . . . 31. var. **unifoliata**

A. Leaves typically pinnate (5–21 leaflets), but sometimes unifoliolate to trifoliolate, petiole over 2 mm.; margin of keel always entire . . . . . B

B. Leaves always pinnate (5–21 leaflets), never unifoliolate, bifoliolate, or trifoliolate; leaflets 6–9 mm. broad, 12–26 mm. long; keel oblong-lanceolate, apex acute . . . . . 33. var. **kanaioensis**

B. Leaves pinnate (5–11 leaflets), but sometimes unifoliolate, bifoliolate or trifoliolate; leaflets 6–14 mm. broad, 18–49 mm. long; keel oblong, apex obtuse . . . . . 32. var. **elliptica**

31. **Sophora chrysophylla** ssp. **unifoliata** var. **unifoliata** Rock, Hawaii Bd. Commrs. Agr. and Forestry, Div. Forestry, Bot. Bul. 5: 44, 1919.

Figs. 16*c*, *d*, 19

Edwardsia unifoliata (Rock) Degener, Flora Hawaiiensis, family 169c, 1932.

Sophora unifoliata (Rock) Degener and Sherff, in Sherff, Bot. Leaflets 5: 24, 1951.

Leaves alternate, usually unifoliolate, but sometimes bifoliolate or trifoliolate; petiole up to 2 mm.; the petals of the keel oblong, the apex obtuse, the base cuneate on one side and truncate on the other side, the margin irregularly indented toward the base.

TYPE: **Hawaii,** Puu Waawaa, 2,000 feet, Aug., 1917, *Rock 13,011* (BISH) (st. lv. bd. fl.).

SPECIMENS EXAMINED: **Hawaii,** Puu Waawaa—1913, *Young 12,648* (st. lv. bd.); 900 m., wood sample no. phloem 180, Dec. 1, 1926, *MacDaniels* (st. lv. fl.); *Meebold* (*Degener's*) *10,138* (st. lv. bd. fl.).

Meebold's specimen shows a double pistil on all of the flowers, while Rock's type specimen does not show such an abnormality. The one flower on MacDaniels' specimen showed a development toward a double pistil, since there was a longitudinal depression.

Fruits were found in an envelope on the sheet of Young's specimen, which probably do not belong to this particular collection, since Rock (1919: 44) states, "no pods seen." The envelope on this sheet appears to be of recent origin, and later collectors failed to find any pods.

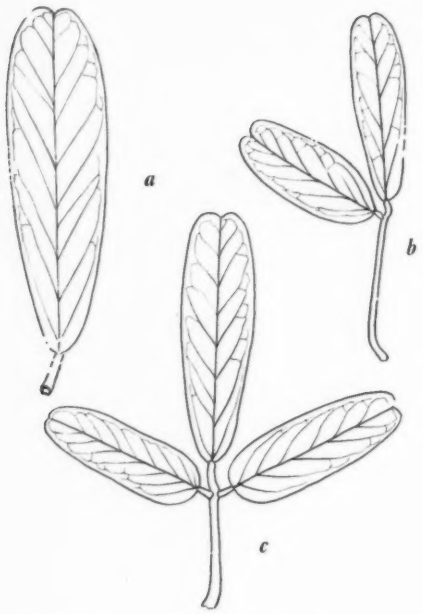

FIG. 17. Leaves of var. *elliptica*, Degener et al. 19,327: *a*, unifoliolate leaf, × 1; *b*, bifoliolate leaf, × 1; *c*, trifoliolate leaf, × 1.

32. **Sophora chrysophylla** ssp. **unifoliata** var. **elliptica,** var. nov.
Figs. 1*b*, 17, 18*a*, *b*, 19

Foliis unifoliolatis vel pinnatis; petalis carinae oblongis, apice obtusis.

Leaves pinnate, but sometimes unifoliolate, bifoliolate or trifoliolate, 6–14 mm. broad, 18–49 mm. long; the standard with the apex retuse, the base cuneate, 16 mm. broad, 20 mm. long; the petals of the wing 5 mm. broad, 21 mm. long; the petals of the keel oblong, the apex obtuse, the base cuneate on one side and hastate on the other side.

TYPE: **Maui,** Hokukano, Dec. 27, 1948, *Degener, Bertram, Clay 19,327* (type, BISH; isotype, F) (st. lv. bd. fl.).

This variety has pinnate, unifoliolate, bifoliolate, and trifoliolate leaves, and represents a transitional stage between var. *unifoliata* and the more common mamane. It is named for the elliptic standard petal.

33. **Sophora chrysophylla** ssp. **unifoliata** var. **kanaioensis,** var. nov.
Figs. 18*c*, *d*, 19

Foliis pinnatis; vexillo oblonge elliptico; petalis carinae oblonge lanceolatis, apice acutis.

Leaves alternate, always pinnate; leaflets oblong to oblong-obovate, 6–9 mm. broad, 16–26 mm. long; rachis-petiole up to 5 cm. long; calyx tube prominently nerved; corolla orange (according to Forbes' label); the

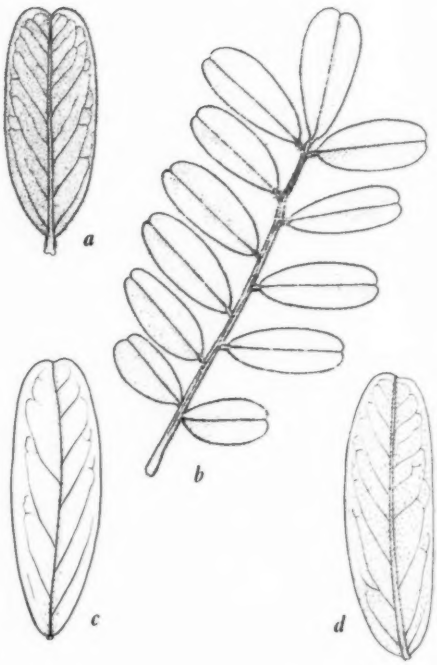

FIG. 18. Pinnate leaf of var. *elliptica*, Degener et al. 19,327: *a*, leaflet, lower surface, × 2; *b*, pinnate leaf, upper surface, × 1. Leaflet of var. *kanaioensis*, Forbes 1807M: *c*, upper surface, × 2; *d*, lower surface, × 2.

standard oblong-elliptic, the apex retuse, the base obtuse, 12 mm. broad, 18 mm. long; the petals of the wing 3 mm. broad, 20 mm. long, the base 4 mm.; the petals of the keel oblong-lanceolate, the apex acute, the base hastate.

TYPE: **Maui,** Kanaio, Mar. 2, 1920, *Forbes 1807M* (BISH) (st. lv. bd. fl.).

SPECIMENS EXAMINED: **Maui,** Kanaio, Feb. 27, 1952, *Degener 21,976* (F) (st. lv. bd. fl. fr.).

This form is named in allusion to its occurrence near Kanaio on the island of Maui.

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HAWAIIAN ISLANDS ASSEMBLED

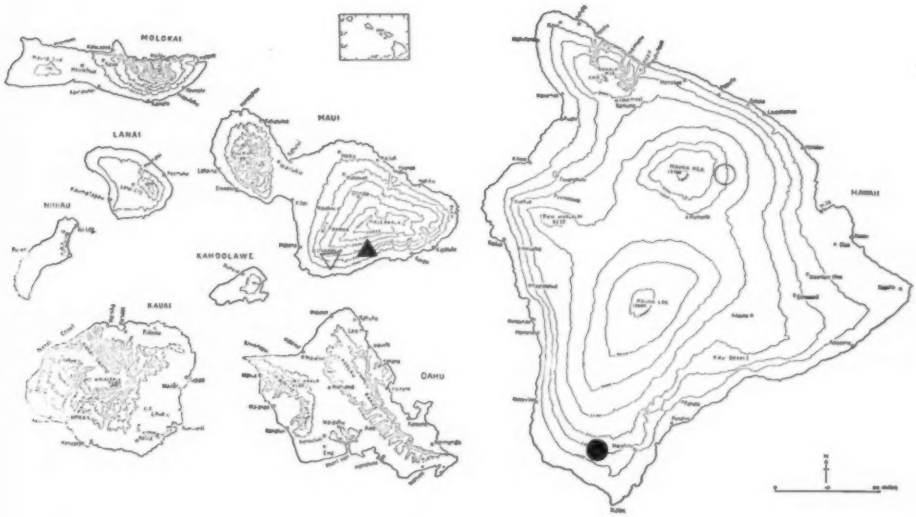

FIG. 19. Map of distribution of *Sophora chrysophylla:* ssp. *circularis*—open circle represents var. *circularis*, solid circle var. *kauensis;* ssp. *unifoliata*—open erect triangle represents var. *unifoliata*, solid erect triangle var. *elliptica*, open inverted triangle var. *kanaioensis*.

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A Revision of the Surgeon Fish Genus *Acanthurus*[1]

JOHN E. RANDALL

THIS IS THE FOURTH in a series of papers dealing with the surgeon fishes (family Acanthuridae). An analysis of the genera and revisions of *Zebrasoma*, *Paracanthurus*, and *Ctenochaetus* have been published (Randall, 1955*a*, *b*, *c*). *Acanthurus*, with 32 species (one of which is described as new), is treated in the present paper, the first to consider all of the species of this circumtropical genus since the review by Günther in 1861.

The work has been based primarily on the collections of surgeon fishes in the following institutions: United States National Museum, Stanford Natural History Museum, California Academy of Sciences, Museum of Comparative Zoology at Harvard College, Bernice P. Bishop Museum, Academy of Natural Sciences of Philadelphia, University of Hawaii, University of Miami, University of California at Los Angeles, and the Pacific Oceanic Fishery Investigations, Honolulu.

I acknowledge with gratitude the assistance and guidance of William A. Gosline of the University of Hawaii and Leonard P. Schultz, Ernest A. Lachner, Robert H. Kanazawa, and Frederick M. Bayer of the United States National Museum.

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I am grateful to L. Bertin of the Museum National d'Histoire Naturelle at Paris, W. Klausewitz of the Senckenberg Museum at Frankfurt, N. B. Marshall and especially Alwyne C. Wheeler of the British Museum of Natural History who have been most cooperative in supplying information on type specimens.

I am most appreciative of the assistance and advice of the research laboratories of the Eastman Kodak Company on the colored plates and for the printing of Plate 2.

E. J. Brill of Leiden, Netherlands, have kindly permitted the use of the figure of *Acanthurus leucosternon* published as Figure 26 of Volume IX of *Fishes of the Indo-Australian Archipelago* by L. F. deBeaufort and W. M. Chapman.

Most of the species of *Acanthurus* are wide-ranging and have been described many times under different names. A total of 110 Recent specific names, discounting misspellings, have been proposed for *Acanthurus* and its synonyms, and seven names from other surgeon

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fish genera have been applied to species of the genus.

In the preparation of the synonymy for each species, mere listings or names with insufficient descriptive data have been omitted generally unless I have seen the specimens reported. References in the synonymy are given with no locality when an author did not cite the locality or when he based his record on the work of a previous author. Misidentifications are indicated by a period immediately following the specific name.

The original descriptions of a few species for which there are no known types are so fragmentary (or in cases probably erroneous) that it would be pure guess work to allocate the names to known forms. In this category are the following: *Acanthurus Militaris* Shaw, *Acanthurus Umbratus* Shaw, *Acanthurus Meleagris* Shaw, *Acanthurus fuliginosus* Lesson, *Acanthurus fraterculus* Cuvier and Valenciennes, and *Acanthurus lineolatus* Cuvier and Valenciennes.

The only species of *Acanthurus* described by Shaw (1803) which has been recognized is *A. achilles*. I have never seen other Shaw names used, and the descriptions are much too brief to permit identifications. A. C. Wheeler of the British Museum answered my query about types by writing, "I have searched everywhere for Shaw's types, and I am quite certain that they are now not in existence, be they in spirit, stuffed, or skins."

Acanthurus fuliginosus was figured by Lesson (1830: pl. 27, fig. 2) as a uniformly brown fish with a broad bright blue line under the chin. In life there were fine, transverse, reddish lines on the body. I know of no species with such coloration. Certainly the use of the name by Fowler, Schultz, and others for *Acanthurus xanthopterus* Cuvier and Valenciennes is not proper, as has been pointed out by de Beaufort (1951: 159).

Acanthurus fraterculus Cuvier and Valenciennes was described from a figure by Renard as brown with three oblique blue and red bands on each side of the head, a blue spot below the middle of the dorsal fin, and green fins except the spinous dorsal which is blue and yellow. Although Günther (1861: 341) listed this species, he added that it had not been recognized.

Chaetodon elongatus Lacépède (1803: 454) is a special problem. It is a species of *Acanthurus*, and the type (No. A. 2506) is in the Paris Museum. L. Bertin (personal communication) writes that it is 90 mm. in standard length, has 16 upper teeth, and a caudal concavity of 4 mm. He adds that the specimen is dry, in very poor condition, and with no color markings perceptible. Günther (1861) listed *A. elongatus* as a questioned synonym of *Acanthurus nigrofuscus* (Forskål); the most frequent use of the name *elongatus* has been for *A. nigrofuscus;* however *A. elongatus* could not be this species. A 90 mm. specimen of *A. nigrofuscus* would have, at most, 12 upper teeth and would have a caudal concavity of about 16 mm. *Acanthurus elongatus* is probably a subadult of one of the larger species of *Acanthurus* such as *A. dussumieri* Cuvier and Valenciennes, *A. xanthopterus* Cuvier and Valenciennes, or *A. mata* (Cuvier). It is difficult to identify even fresh specimens of 90 mm. length of species in this complex. Because of the apparent juvenile nature and poor state of preservation of the type specimen, coupled with the inadequate original description, *elongatus* should be considered a *nomen inquirendum*.

Acanthurus rackliffei Schultz (1943: 157, 163, fig. 13) is probably a hybrid of *Acanthurus achilles* Shaw and *Acanthurus glaucopareius* Cuvier (Randall, in press, *d*).

Sauvage (1891: 519) listed *lunulatus* Liénard among the species of *Acanthurus* from Madagascar. I am unable to find the work of Liénard in which this species was described. This author was at times nonbinominial.

Acanthurus doreensis Cuvier and Valenciennes is here treated as a doubtful species.

Some species of *Acanthurus* have been described from the late postlarval or acronurus stage, and many of these were originally

placed in the genus *Acronurus* Gronow. The larval nature of *Acronurus* has been known at least since Günther (1873); nevertheless as recently as 1944 Fowler described a new species in the genus. It has not been possible in most cases for me to determine the correct adult name for species described from acronurus or early juvenile stages. The following such species I cannot place, with assurance, in synonymy: *Acronurus orbicularis* Quoy and Gaimard, *Acronurus fuscus* Gronow, *Acronurus anginosus* Bleeker, *Acronurus brevispinis* Günther, *Acronurus argenteus* Günther (not of Quoy and Gaimard), *Acronurus melanurus* Day, *Acronurus carneus* Poey, *Acronurus lineolatus* Klunzinger, *Acronurus machaeropterus* Fowler, *Acanthurus melanurus* Cuvier and Valenciennes, *Acanthurus melas* Cuvier and Valenciennes, *Hepatus leucopareius* Fowler (from Guam), *Teuthis elongatus* Kendall and Goldsborough, *Hepatus elegans* Kamohara (not of Garman), and *Teuthis spinifrons* Whitley.

I have been more successful in identifying to species actual museum specimens of acronurus forms and early juveniles. Some of these are shown in Figure 1. The adults of all of the species of *Acanthurus* are figured.

I have seen specimens of all of the known species of *Acanthurus* except *A. polyzona* (Bleeker), *A. leucocheilus* Herre, and *A. mindorensis* Herre. A. W. Herre has informed me that the types of the latter two were destroyed at Manila. To my knowledge there are no other specimens in existence. The specimens which Herre (1934: 62) identified as *A. leucocheilos* [*us*] are *Acanthurus pyroferus*.

Like most fishes, there are some obvious differences with age in species of *Acanthurus*. With increasing age, the eye becomes relatively smaller, the caudal fin generally more lunate, and in many species the body is more elongate; the teeth increase in number and at least in some species (see Table 16 under *A. gahhm*) the number of denticulations on the teeth decrease (for this reason the lengths are given for specimens from which teeth are taken for the tooth drawings of Fig. 2). Most striking in many species are the color changes with age. Examples are as follows: the young of *A. coeruleus* Bloch and Schneider and *A. olivaceus* Bloch and Schneider are solid yellow in color; the distinctive mark found on the shoulder region of many of the species of *Acanthurus* is not present in juveniles; the semicircular black shoulder mark of *A. tennenti* Günther changes in older individuals to two elongate black bands; *A. achilles* does not develop its bright orange spot on the caudal peduncle until it has attained a size of about 65 to 70 mm.

Two keys are given, one to the Indo-Pacific species and one to the Atlantic species, not because there are any marked differences between the species of these two major regions, but as a convenience to the reader. The species are keyed out, insofar as possible, in natural groups (as based on superficial characters). These species groups are not sufficiently demarked from one another, in my opinion, to be regarded as subgenera. They are as follows:

1. *A. triostegus* (Linnaeus) and *A. polyzona* (Bleeker).
2. *A. nubilus* (Fowler and Bean), *A. bleekeri* Günther, and *A. thompsoni* (Fowler).
3. *A. nigrofuscus* (Forskål), *A. nigroris* Cuvier and Valenciennes, *A. leucopareius* (Jenkins), *A. guttatus* Bloch and Schneider, and possibly *A. coeruleus* Bloch and Schneider.
4. *A. lineatus* (Linnaeus) and *A. sohal* (Forskål).
5. *A. achilles* Shaw, *A. glaucopareius* Cuvier, and *A. leucosternon* Bennett.
6. *A. pyroferus* Kittlitz.
7. The remaining three Atlantic species and the last 11 Indo-Pacific species (*A. leucocheilus* and *A. mindorensis* not considered).

A. pyroferus is placed by itself because of its intermediacy between Groups 5 and 7; this is discussed in detail under *A. pyroferus*.

Group 7 constitutes a superspecific assemblage which has as its most characteristic

feature a large, round, thick-walled stomach. Such a gizzard-like stomach is not found in any other *Acanthurus* except *A. pyroferus*. These species are commonly found in bay or lagoon environments, and the gut contents generally contain a large percentage of hard, coarse, sedimentary material. The teeth tend to be elongate with numerous denticulations. Eight of the Indo-Pacific species develop with age a distinctive color mark in the shoulder region just above the gill opening. In most of the species the caudal spine is accentuated by being surrounded with color (often black or dark brown). They are not exclusive in this feature, however, for *Acanthurus achilles*, *Acanthurus sohal*, and certain species of *Naso* have their caudal spines contained within areas of bright color. Presumably this color serves as warning coloration, a means of calling attention to the sharp caudal spines. There is a tendency in this group toward large size, this being most apparent in *A. xanthopterus*, *A. dussumieri*, and *A. mata*.

It is only in this last group of species that I have observed sexual dimorphism in *Acanthurus*. Large adult males develop a definite convexity in the profile of the head above the mouth. Although there is a tendency for the profile to become more convex regardless of sex, it is much more evident in males than in females of the same size.

TABLE 1
DISTRIBUTION OF THE SPECIES OF *Acanthurus*

MAJOR TROPICAL AND SUBTROPICAL REGIONS	NO. OF SPECIES KNOWN TO OCCUR IN REGION	NO. OF SPECIES CONFINED TO REGION
Indo-Pacific (28 species)		
Indian Ocean	13*	3†
Common to Indian Ocean and Indo-Malaya	12	2
Indo-Malayan region‡	23	6
Common to Indo-Malaya and Oceania	15	5
Oceania§	17	2
Common to Indian Ocean and Oceania	10	8
Eastern Pacific	3	0
Atlantic (4 species‖)		
Western Atlantic	3	2
West Africa	2	1

* *Acanthurus glaucopareius* is recorded from Christmas Island and Cocos-Keeling Islands in the Indian Ocean. Since these are near the East Indies and the species is unknown from the rest of the Indian Ocean, it is not included in this figure.

† Includes *Acanthurus sohal*, a species known only from the Red Sea.

‡ East Indies, northern Australia, Malaya, and Philippine Islands.

§ Oceanic islands of the tropical western, southern, and central Pacific Ocean.

‖ The Indo-Pacific *Acanthurus triostegus* is not included in this figure, although there is one record of this species from West Africa.

DISTRIBUTION

The distribution of the species of *Acanthurus* as indicated in the keys and Table 1 is based on localities of museum specimens seen by me and records from the literature about which there is little or no question. Further collecting may result in the extension of the range of some of the species.

Like most widely-distributed genera of tropical marine fishes, the greatest number of species of *Acanthurus* occurs in the Indo-Malayan region.[2] Twenty-three are recorded from the East Indies and Philippines, six of which are endemic to the area. This is a higher degree of endemism than that of any other region.

Only two species of *Acanthurus*, *A. achilles* and *A. leucopareius*, appear to be confined to oceanic islands of the Pacific. The latter is known by authentic records only from the Hawaiian Islands, Marcus Island, and Easter Island, areas widely separated and peripheral in Oceania, suggesting that *A. leucopareius* may be a relict species.

[2] The surgeon fish genera *Zebrasoma* and *Ctenochaetus*, however, do not follow this pattern. Of the six species of *Zebrasoma*, none are endemic to the Indo-Malayan region; two are confined to the Indian Ocean and two to the Pacific. Although two of the seven species of *Ctenochaetus* are restricted to the East Indies and Philippines, three are known only from islands in the central and eastern Pacific.

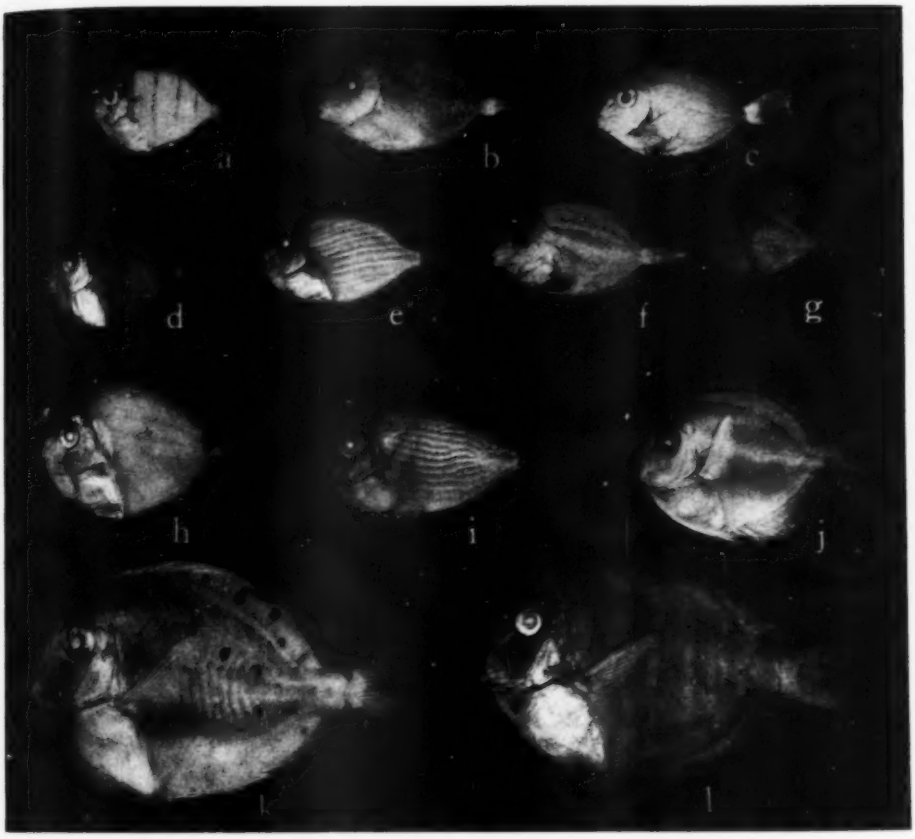


FIG. 1. Acronurus and very young juvenile stages (as indicated) of species of *Acanthurus: a, triostegus triostegus*, Guam, U.S.N.M. No. 139750; *b, chirurgus*, Puerto Rico, U.S.N.M. No. 73825, (juvenile); *c, bahianus*, Puerto Rico, U.S.N.M. No. 147648, (juvenile); *d, mata*, Oahu, Hawaiian Islands, U.S.N.M. No. 167248; *e, lineatus*, Mariana Islands, U.S.N.M. No. 139759; *f, olivaceus*, Eniwetok, Marshall Islands, U.S.N.M. No. 139998, (juvenile); *g, sohal*, Jidda, Red Sea, U.S.N.M. No. 147552; *h, dussumieri*, Oahu, Hawaiian Islands, U.S.N.M. No. 167247; *i, nigroris*, Wake Island, U.S.N.M. No. 167249; *j, guttatus*, Tau, Phoenix Islands, U.S.N.M. No. 115134; *k, achilles*, Oahu, Hawaiian Islands, U.S.N.M. No. 150744; *l, glaucopareius*, Kwajalein, Marshall Islands, U.S.N.M. No. 139955.

Acanthurus lineatus, though widely distributed, is not reported from the Red Sea. The species which most resembles *A. lineatus* is *A. sohal*. The latter appears to be restricted to the Red Sea. *A. achilles* and the similar *A. leucosternon* are not recorded from the same area; *A. achilles*, as mentioned, seems to be characteristic of Oceania whereas *A. leucosternon* is an Indian Ocean and East Indian species. The Indian Ocean species *A. tennenti* is very closely related to *A. olivaceus*. The latter, however, does not seem to occur in the Indian Ocean, but ranges from the East Indies into the tropical Pacific. Although further collecting may result in the two species of these three pairs being found together, it may be

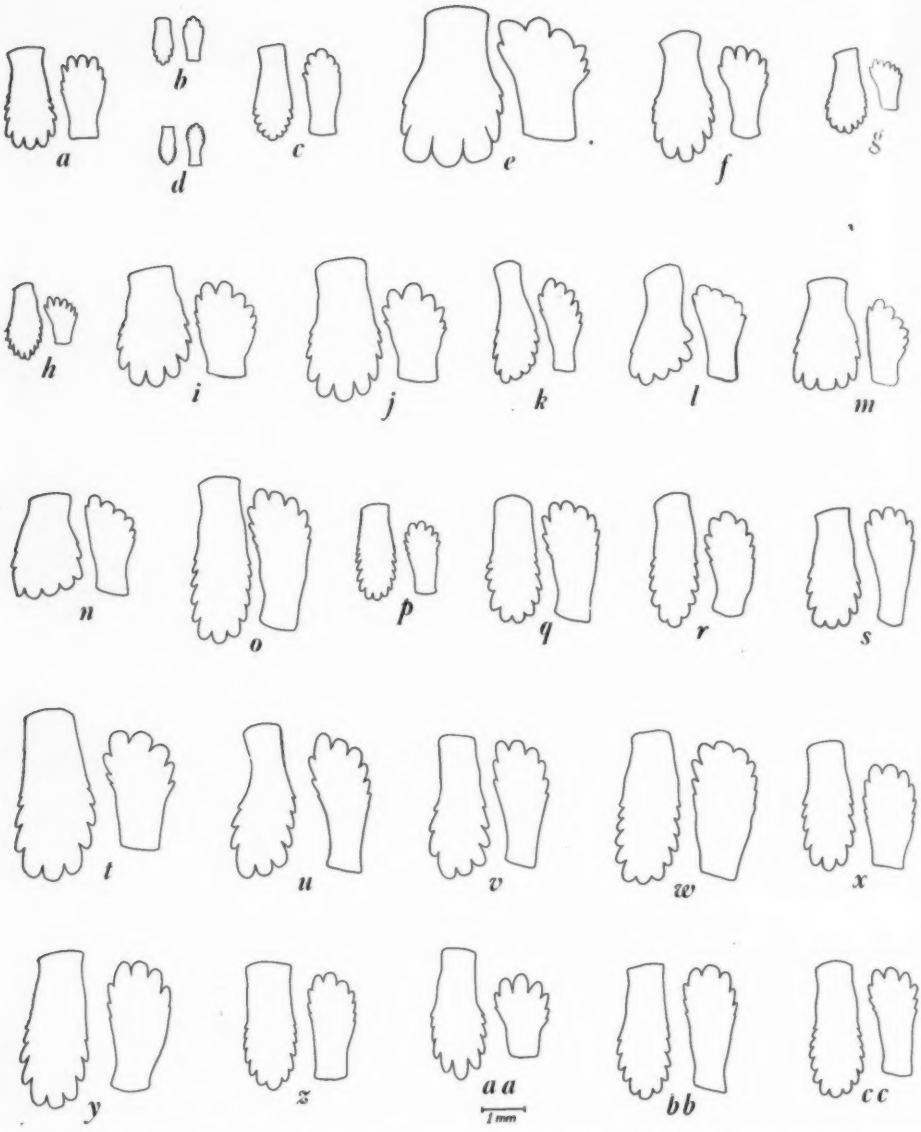


FIG. 2. Camera lucida drawings of upper (left) and lower (right) teeth of various species of *Acanthurus*. Teeth were taken from right side of jaws near center and drawn in inner or lingual view. *a*, *triostegus*, 140 mm. specimen, Marshall Islands; *b*, *nubilus*, 156 mm. specimen, East Indies; *c*, *bleekeri*, 223 mm. specimen, Philippine Islands; *d*, *thompsoni*, 138 mm. specimen, Gilbert Islands; *e*, *guttatus*, 165 mm. specimen, Gilbert Islands; *f*, *leucopareius*, 156 mm. specimen, Hawaiian Islands; *g*, *nigroris*, 81 mm. specimen, Marshall Islands; *h*, *nigrofuscus*, 81 mm. specimen, Marshall Islands; *i*, *lineatus*, 150 mm. specimen, Gilbert Islands; *j*, *sohal*, 203 mm. specimen, Red Sea; *k*, *pyroferus*, 143 mm. specimen, Philippine Islands; *l*, *leucosternon*, 173 mm. specimen, Mauritius; *m*, *glaucopareius*, 143 mm. specimen, Marshall Islands; *n*, *achilles*, 137 mm. specimen, Phoenix Islands; *o*, *olivaceus*, 190 mm. spec-

worth noting at this time that they may be species which will not co-exist due to similarities in ecological tolerances (Gause, 1934). I suspect that this may be the explanation because of the apparent ease with which species of *Acanthurus* achieve wide distribution (probably because of long planktonic larval life). Since *A. olivaceus*, for example, ranges from the East Indies throughout Oceania, it would be expected to occur also in the Indian Ocean in view of existing current patterns.

The possibility that two species of *Ctenochaetus* may be mutually exclusive also bears checking. *C. magnus* Randall is known thus far from only three localities, Jarvis Island, Malden Island, and Cocos Island (off Costa Rica). The usually abundant *C. striatus* (Quoy and Gaimard) has not been collected from any of these islands, although it would not be expected at Cocos since this species does not appear to be among the few surgeon fishes to have crossed the Eastern Pacific Barrier (see Ekman, 1953).

One of the Atlantic species, *Acanthurus chirurgus* (Bloch) is very similar to the Indo-Pacific *A. xanthopterus* which occurs on the Pacific coast of Mexico and Central America, where it has usually been known by the name *Acanthurus crestonis* (Jordan and Starks). Although not included among the geminate species (listed by Jordan 1908: 76) which occur on either side of the isthmus of Panama, these two might qualify as another example.

The three Atlantic species which are common in the West Indies and Florida are occasionally taken as far north as New York and Massachusetts. It is believed that these species are not resident in such northern localities but represent individuals carried northward as larvae by the Gulf Stream.

The acronurus of *Acanthurus triostegus* is taken farther south on the southeast coast of Africa than are adults (Smith, 1949: 240 and by personal communication). The strong southerly current in this region is probably responsible. The same thing appears to be true of several species of surgeon fishes on the east coast of Australia (Whitley, 1953).

METHODS OF COUNTING AND MEASURING

Each ray of the dorsal and anal fins with a distinct base was counted regardless of how close adjacent rays might be. In cases where two rays branch from a common base, they were counted as one. At times dissection was necessary to determine whether the last two rays originate from a single basal element. Pectoral fin ray counts include the two uppermost unbranched rays, the first of which is a short bony spicule.

The gill rakers are small and occur in two distinct series, one on each side of the gill arch. Counts of both series are of diagnostic importance in *Acanthurus*. The usual gill raker counts are here designated anterior; those on the posteromedial side of the arch are called posterior. Gill raker counts were made on the first arch and include all rudiments. The raker counts were made on five specimens unless otherwise stated.

The scales are small and do not occur in regular rows. Successive trials at counting scales on the same specimen rarely resulted in the same count. The only scale counts which are recorded are those for the one new species.

The standard length is measured from the tip of the snout to the base of the caudal fin (end of hypural plate). All references to length of specimens are standard length. Head length is taken from the tip of the snout horizontally to a vertical at the most posterior end of the

imen, Marshall Islands; *p*, *tennenti*, 115 mm. specimen, locality unknown; *q*, *fowleri*, 198 mm. specimen, Philippine Islands; *r*, *bariene*, 169 mm. specimen, Philippine Islands; *s*, *gahbm*, 179 mm. specimen, Phoenix Islands; *t*, *maculiceps*, 194 mm. specimen, Gilbert Islands; *u*, *auranticavus*, 205 mm. specimen, Philippine Islands; *v*, *grammoptilus*, 204 mm. specimen, Philippine Islands; *w*, *dussumieri*, 210 mm. specimen, Hawaiian Islands; *x*, *xanthopterus*, 200 mm. specimen, Gilbert Islands; *y*, *mata*, 228 mm. specimen, Wake Island; *z*, *monroviae*, 192 mm. specimen, Liberia; *aa*, *coeruleus*, 127 mm. specimen, Haiti; *bb*, *chirurgus*, 178 mm. specimen, Cuba; *cc*, *bahianus*, 168 mm. specimen, Cuba.

opercular membrane. Body depth is the distance from the natural groove at the base of the second anal spine to a similar groove at the base of the dorsal fin. Caudal concavity is the distance between vertical lines passing through the tips of the shortest middle caudal rays and the longest ray of the dorsal lobe of the caudal fin. This measurement is not made from a compressed or stretched caudal fin, but one in the normal resting position as shown in the figures of the various species.

ACANTHURUS Forskål

Acanthurus Forskål (1775: 59). Type species by subsequent designation (Jordan, 1917), *Chaetodon sohal* Forskål.

Body compressed, elliptic, the depth contained 1.55 to 2.5 in standard length; head length 3 to 4.3 in standard length; caudal peduncle with a single sharp folding spine on each side, fitting into a definite socket; length of caudal spine 1.9 to 13 in head length; least depth of caudal peduncle 1.9 to 3.1 in head length; mouth small, terminal, and only slightly protractile; jaws equal; teeth close-set, compressed, denticulate, 8 to 24 in upper jaw and 10 to 24 in lower jaw; dorsal fin with VI to IX (usually IX) spines and 22 to 33 rays; anal fin with III spines and 19 to 29 rays; pectoral fin rays 15 to 17; pelvic fin with I spine and 5 rays; caudal fin with 16 principal rays; caudal fin varying in shape from nearly truncate to very lunate; dorsal and anal fins continuous and unnotched; longest dorsal ray 3.5 to 6 in standard length; longest anal ray 3.8 to 7 in standard length; length of pectoral fin 2.7 to 3.8 in standard length; length of pelvic fin 3.2 to 5.5 in standard length; origin of pelvic fin at or slightly posterior to a vertical through middle of base of pectoral fin; diameter of eye in adults 2.8 to 5.7 in head length; interorbital space 2.5 to 3.6 in head length; snout length 3.9 to 8.2 in standard length; gill openings restricted to sides; gill membranes attached to isthmus; anterior gill rakers 13 to 29; posterior gill rakers 13 to 32; scales ctenoid, very small, and not in regular rows; head scaled, though not conspicuously; lateral line complete; 22 or 23 vertebrae; stomach varies from round and heavy-walled to elongate and thin-walled.

Agassiz (1833–43: vol. 4, p. 207, pl. J) discussed the osteology of *Acanthurus*. Günther (1861: 327) described the osteology of *Acanthurus triostegus*, and Gregory (1933: fig. 156) figured the skull of this species. Souche (1935) made an anatomical study of the musculature of the caudal spine of *Acanthurus chirurgus*. Willem (1944) studied the respiratory system of *Acanthurus triostegus* along with that of other species.

Plate 5, figures 3, 4, and 5 of Lütken (1880) represent the postacronurus, acronurus, and postlarval forms, respectively, of *Acanthurus coeruleus*. His figure 5 was drawn from a 5.7 mm. specimen. Weber (1913: fig. 70) figured a 7 mm. postlarval stage of an unidentified species of *Acanthurus*.

The genus *Acanthurus* is known by the common names surgeon fish, doctor fish, and tang. The species are, in general, herbivorous.

The gender of the name *Acanthurus* is uncertain. The probable derivation of this generic name is from the Greek *acantha* (thorn, fem.) and the Greek *oura* (tail, fem.). If properly latinized, it would have been *Acanthura*. Forskål, who proposed the name more-or-less as a subgenus and never used it in combination with a specific name, probably intended that it be masculine. Subsequent authors, including those who wrote primarily in latin, have consistently treated the genus as masculine, and I concur in this.

For a review of the generic synonymy of *Acanthurus* and a key to all the genera of the Acanthuridae, see Randall (1955*a*).

KEY TO THE SPECIES OF *Acanthurus* OF THE INDIAN AND PACIFIC OCEANS

(See page 165 for methods of counting and measuring.)

1a. Body light in color with vertical black bars; caudal fin truncate or slightly

emarginate, caudal concavity contained more than 15 times in standard length; caudal spine very small 2

1b. Body not light in color with vertical black bars; caudal fin, at least in adults, emarginate to lunate, caudal concavity contained less than 15 times in standard length (except *guttatus*); caudal spine usually not small 3

2a. 6 vertical black bars (1 on head passing through eye; 4 on side of body; 1 on caudal peduncle); bars on side of about uniform width; anal soft rays 19 to 22; dorsal soft rays 22 to 24 (excluding fin ray counts of the species in Hawaii). (Indo-Pacific) . . . . **triostegus**

2b. 12 vertical black bars (4 on head, the longest passing through eye; 6 on side of body; 2 on caudal peduncle); bars on side about five times as broad dorsally as ventrally; anal soft rays 21 to 23; dorsal soft rays 23 to 25. (Réunion Island, Indian Ocean) (after Bleeker) . . . . . **polyzona**

3a. Snout short, its length contained 6.6 to 8.2 times in standard length; mouth small and teeth small and numerous, 22 or more in lower jaw of adults 4

3b. Snout not short, its length contained 3.9 to 5.3 times in standard length; mouth usually not small (if small, not more than 12 teeth in lower jaw) and teeth not small and numerous, 22 or less (rarely 22) in lower jaw of adults 6

4a. Dorsal spines VI or VII; body depth 1.8 in standard length; anterior gill rakers 21; posterior gill rakers 24 (based on 1 specimen). (Philippine Islands and East Indies) . . . . . **nubilus**

4b. Dorsal spines IX; body depth 2.1 to 2.5 in standard length; anterior gill rakers 13 to 17; posterior gill rakers 13 to 15 . 5

5a. Lengthwise blue lines on side of head and body (may be faded in preserved specimens); snout 6.6 to 7.1 in standard length; least depth of caudal peduncle 2.7 to 3 in head length; no dark brown spot just below axil of pectoral fin; maximum standard length about 300 mm. (Indo-West-Pacific, except Hawaii) . . . . . **bleekeri**

5b. No lengthwise blue lines on side of head and body; snout 7.9 to 8.2 in standard length; least depth of caudal peduncle 2.2 to 2.5 in head length; a dark brown spot just below axil of pectoral fin; maximum standard length about 150 mm. (East Indies, Philippine Islands, and Oceania) . . . . . **thompsoni**

6a. Mouth low in origin on head and produced; a deep brown ring at base of caudal fin; all fins black. (Philippine Islands) (after Herre) . . . **mindorensis**

6b. Mouth not low in origin on head and usually not produced; no deep brown ring at base of caudal fin; all fins not black 7

7a. Posterior half of body and dorsal and anal fins with numerous white spots on a brown background; body with 3 vertical whitish bars, the first running from occiput to opercle, the second from base of third and fourth dorsal spines to region of anus, and the third from base of first few dorsal soft rays to base of first few anal soft rays; body very deep, greatest depth 1.5 to 1.6 in standard length. (Indo-West-Pacific) . . . **guttatus**

7b. Posterior half of body without numerous white spots; body without 3 vertical whitish bars; body not very deep, greatest depth 1.7 to 2.5 in standard length . 8

8a. A black spot at base of last few rays of both the dorsal and anal fins (spot in axial of anal fin in *leucopareius* very small) 9

8b. No black spot at base of last few rays of dorsal and anal fins . . . . . : **11**

9a. A whitish band, broadly bordered by dark brown bands, running from origin of dorsal fin across operculum just behind eye (faded in some specimens); caudal fin with no white posterior margin; caudal fin emarginate, caudal concavity 10.5 to 12 in standard length of adults; body depth 1.7 to 1.8 in standard length; anterior gill rakers 15 to 18. (Hawaiian Islands, Marcus Island, and Easter Island) . . . . . **leucopareius**

9b. No whitish band running from origin of dorsal fin across operculum; caudal fin with a white posterior margin; caudal fin moderately concave to lunate, caudal concavity 4.5 to 10 in standard length; body depth 1.8 to 2.3 in standard length; anterior gill rakers 20 to 29 . . . . . **10**

10a. Caudal fin moderately concave, caudal concavity 5.8 to 10.5 in standard length; black spot at axil of soft dorsal fin not large, its greatest width contained more than 2 times in diameter of eye; white posterior margin of caudal fin narrow, its width rarely less than 4 in pupil; no definite black margin around groove of caudal spine; body depth 1.8 to 2 in standard length; ends of median upper teeth rounded (Fig. 2*g*); maximum standard length about 200 mm.; no orange spots on head in life. (East Indies, Philippine Islands, and Oceania) . . . . . **nigroris**

10b. Caudal fin lunate, caudal concavity 4.5 to 6 in standard length; black spot at axil of soft dorsal fin large, its greatest width contained less than 2 times in diameter of eye; white posterior margin of caudal fin not narrow, its greatest width about 2 in pupil (in specimens from Oceania); a definite black margin around groove of caudal spine; body depth 2 to 2.3 in standard length; ends of median upper teeth tend to be pointed (Fig. 2*b*); maximum standard length about 150 mm. (rarely over 120 mm.); orange spots on head in life (which usually fade in preservative). (Indo-West-Pacific) . . . . . **nigrofuscus**

11a. Upper ¾ of body with conspicuous lengthwise black bands and in sharp contrast to uniform light grayish brown of lower ¼; caudal spine very long (1.9 to 2 in head length) and without a definite sheath; posterior gill rakers 13 to 15; anterior gill rakers 14 to 17 . . . . . **12**

11b. Body without conspicuous lengthwise black bands; caudal spine not very long (2.1 to 8 in head length) and with a definite sheath; posterior gill rakers 17 to 32; anterior gill rakers 16 to 29 . . . . . **13**

12a. Dorsal rays **IX**, 27 to 29; about 7 black lengthwise bands on body below lateral line (anteriorly), each bissected with a blue line and alternating with whitish (yellow in life) lines; median and pelvic fins not black. (Indo-West-Pacific, but not Hawaii) . . . . . **lineatus**

12b. Dorsal rays **VIII**, 30 to 31; about 15 black lengthwise bands on body below lateral line (anteriorly), none bissected with blue lines and not alternating with whitish lines (the narrow intermediate lines of same color as ventral part of body); median and pelvic fins black. (Red Sea) . . . . . **sohal**

13a. Lips reddish in life and surrounded (or nearly surrounded) by a pearly white line with a black band behind it; a bluish white band of about a half an eye diameter in thickness crossing chest slightly anterior to a vertical through center of eye; outer part of soft dorsal fin in life with 3 and anal fin with 2 narrow red lines alternating with bluish lines; pelvic fins brick red with black outer margin. (Philippine Islands) (after Herre) . . . . . **leucocheilus**

13b. Lips not reddish in life and never completely surrounded by a pearly white line with a black band behind it; no bluish white band of about a half an eye diameter in width crossing chest; no red lines in outer part of soft dorsal and anal fins; pelvic fins not brick red with black outer margin 14

14a. Dorsal spines VIII; caudal fin black except for a broad pale (yellow in life) band of near-uniform width on entire posterior margin (hence most of prolonged outer lobes of caudal fin pale); a white line under chin extending slightly above rictus; upper end of gill opening and edge of operculum broadly black; a diffuse orange area in life behind gill opening extending to axil of pectoral fin. (Indian Ocean, East Indies, Philippine Islands, and Western Oceania) . . . . . **pyroferus**

14b. Dorsal spine IX; caudal fin not black with a broad pale posterior margin of uniform width; upper end of gill opening and edge of operculum not broadly black; no diffuse orange area in life behind gill opening extending to axil of pectoral fin 15

15a. Mouth very small, its width from rictus to rictus contained 4.5 to 6 times in length of head; maximum number of upper or lower teeth 12; a white line under chin; depth of body 1.7 to 1.9 in standard length; dorsal soft rays 28 to 33; anal soft rays 26 to 29 16

15b. Mouth not very small, its width from rictus to rictus contained 3.2 to 4.8 times in length of head; maximum number of upper or lower teeth 22 (specimens over 50 mm. in standard length with at least 14 teeth in either jaw); no white line under chin; depth of body 1.9 to 2.5 in standard length; dorsal soft rays 23 to 28; anal soft rays 22 to 26. 18

16a. Isthmus and chest with a chalky white band (as broad as depth of caudal peduncle) extending to base of pectoral fin; body bluish gray in preservative, head dark brown. (East Indies and Indian Ocean) . . . . . **leucosternon**

16b. Isthmus and chest without a broad white band; body and head dark brown to black 17

17a. No large elliptical pale yellowish area posteriorly on body; an oval white spot under eye; no white mark on opercular membrane; white line on chin extending above rictus; pale area at base of dorsal and anal fins very broad posteriorly; caudal fin emarginate, caudal concavity 10 to 14.5 in standard length; dorsal soft rays 28 to 31 (usually 29 or 30); anal soft rays 26 to 28 (usually 26 or 27). (East Indies, Philippine Islands, Oceania, and islands of tropical eastern Pacific) . . . . . **glaucopareius**

17b. A large elliptical pale yellowish area (bright orange in life) posteriorly on body, enclosing in its hind part the caudal spine (this area absent in specimens less than about 65 to 70 mm. in standard length); no oval white spot under eye; an elongate pure white mark on opercular membrane; white line on chin not extending above rictus; pale area at base of dorsal and anal fins narrow and of almost uniform width; caudal fin lunate, caudal concavity 5.5 to 8.5 in standard length; dorsal soft rays 29 to 33 (usually 30 to 32); anal soft rays 26 to 29 (usually 27 to 29). (Oceania) . . . . . **achilles**

18a. A prominent dark mark on shoulder (absent in young) 19

18b. No dark mark on shoulder 25

19a. Shoulder mark semicircular (open end forward at level of eye), a very elongate horizontal ellipse, or two elongate bands

(one above the other); a large crescent-shaped white region posteriorly in caudal fin, its greatest width more than half the diameter of eye; base of caudal fin not pale; anal soft rays 22 to 24; dorsal soft rays 23 to 25; no fine longitudinal lines on body **20**

19b. Shoulder mark a spot, horizontal solid bar, or open triangle or semicircle (open part forward and below level of eye); no large crescent-shaped white region posteriorly in caudal fin (a white posterior margin, if present, of a maximum width of less than ⅓ eye diameter); base of caudal fin pale; anal soft rays 23 to 26; dorsal soft rays 24 to 28; fine longitudinal lines may or may not be present on body **21**

20a. Shoulder mark elongate with pale yellowish (bright orange in life) center; no dark area around caudal spine; white crescent in caudal fin with a narrow black posterior margin; brown portion of caudal fin with dark brown spots; color of young in life solid yellow (pale in preservative). (East Indies, Philippine Islands, and Oceania) . . **olivaceus**

20b. Shoulder mark semicircular with no pale center or (at a size of 100 to 110 mm. or more in standard length) 2 elongate black bands; a black, light bluish-bordered area around caudal spine (this area becoming relatively larger in larger specimens); white crescent in caudal fin without a black posterior margin; caudal fin without brown spots; color of young unknown to me. (Ceylon and Mauritius) . . . . . **tennenti**

21a. Shoulder mark triangular or semicircular with uppermost part just above dorsal end of gill opening and lower part near axil of pectoral fin; posterior gill rakers 29 to 32. (East Indies and Philippine Islands) . . . . . **fowleri**

21b. Shoulder mark a spot or solid bar; posterior gill rakers 17 to 28 . . . . . **22**

22a. Shoulder mark a round black spot (just behind eye), at times with a narrow light bluish border; a blue line at base of dorsal fin in life, usually persisting as a bluish white line on preserved specimens; depth of body 1.9 to 2 in standard length. (East coast of Africa, East Indies, Philippine Islands, and Riu Kiu Islands) . . . . . **bariene**

22b. Shoulder mark a black or dark brown bar; no blue line at base of dorsal fin in life; depth of body 2 to 2.2 in standard length **23**

23a. Caudal fin with a distinct white posterior margin, broader centrally, about ¼ eye diameter in maximum width; a long, pointed, black streak extending anteriorly from caudal spine (first appearing at a size of about 100 mm. and becoming progressively longer in larger specimens until it extends over half distance from caudal spine to base of pectoral fin); length of black shoulder bar (in specimen over 100 mm. in standard length) about 4.5 to 7 in standard length; numerous pale lengthwise lines not present on body; anal soft rays 24 to 26; dorsal soft rays 25 to 28. (Indo-West-Pacific) . . . . . **gahhm**

23b. Caudal fin without a distinct white posterior margin; no long, pointed, black streak extending anteriorly from caudal spine; length of dark shoulder bar about 9 to 13 in standard length; numerous pale lengthwise lines present on body (faint on some specimens); anal soft rays 23 to 24; dorsal soft rays 24 to 26 . . . . . **24**

24a. Head and nape with numerous prominent pale spots; upper distal part of pectoral fin with a large pale yellowish spot; shoulder mark in back of gill

opening black (indistinct above and anterior to gill opening), horizontal, and usually somewhat pointed at end; dorsal fin with about 9 narrow longitudinal bands from base to margin; posterior gill rakers 21 to 24. (East Indies, Philippine Islands, and Gilbert Islands) . . . . . **maculiceps**

24b. Head and nape without pale spots; upper distal part of pectoral fin without a large pale spot; shoulder mark dark brown (indistinct and narrow above gill opening), tilting sharply downward as it passes posteriorly, and rounded at end; dorsal fin without lengthwise bands or with only one or two posteriorly near outer border; posterior gill rakers 25 to 28. (Philippine Islands and East Indies) . . . . . **auranticavus,** n. sp.

25a. Head with small pale (rust color in life) spots; black around caudal spine groove of adults extending ahead of front end of spine (to a distance almost as long as spine in a 245 mm. specimen); caudal fin with a very narrow white posterior margin (broader in young); body depth of adults (over 200 mm. in standard length) 2.2 to 2.5 in standard length. (northern Australia) . . . **grammoptilus**

25b. Head without small pale spots; dark brown or black around groove of caudal spine not extending much beyond front end of spine; caudal fin without a narrow white posterior margin (except in young which may have a very narrow pale margin); body depth of adults 1.9 to 2.1 in standard length **26**

26a. Caudal fin marked with numerous blackish spots; sheath of caudal spine whitish and in sharp contrast to black surrounding caudal spine groove; a pale (yellow in life) band crossing or nearly crossing interorbital space from eye to eye; body with numerous, fine, slightly wavy, pale bluish, lengthwise lines which usually persist in preservative; dorsal fin of adults without alternating dark and light bands or with only a few faint narrow ones in outer portion of fin; eye large, its greatest diameter contained in head length about 3.2 to 4.7 times over the range in standard length of 120 to 300 mm.; anal soft rays 24 to 26. (Indo-West-Pacific) . . . . . **dussumieri**

26b. Caudal fin not marked with blackish spots; sheath of caudal spine brownish; no pale band crossing interorbital space (a pale yellowish area may extend anteriorly from eye but not as a definite band); body without numerous slightly wavy, fine, pale bluish, lengthwise lines (lines, if present, indistinct and broken or coarse and very wavy and rarely evident in preserved specimens); dorsal and anal fins with lengthwise dark brown (blue in life) bands alternating with light brown (yellow in life) bands from base to margin (may fade in preservative, especially in *mata*); eye not large, its greatest diameter contained about 3.9 to 5.4 times in head length over the range in standard length of 120 to 300 mm.; anal soft rays 23 to 25 . . **27**

27a. Outer ⅓ of pectoral fin pale (yellowish in life) and contrasting with darker basal ⅔ of fin (in specimens over about 120 mm. in standard length); dorsal fin with about 4 broad lengthwise bands; caudal fin very lunate, caudal concavity about 4.5 to 7 in standard length; caudal spine usually small, about 4.5 to 5.5 in length of head; dark margin around socket of caudal spine usually narrow and indistinct; white band at base of caudal fin usually not distinct; anterior gill rakers 16 to 22; posterior gill rakers 17 to 22. (Indo-Pacific) . . . . . **xanthopterus**

27b. Pectoral fin uniform brown; dorsal fin (at least in Hawaiian specimens) with about 8 narrow lengthwise bands; cau-

dal fin not very lunate, caudal concavity about 6 to 10 in standard length; caudal spine usually not small, about 3 to 4.2 in length of head; a definite dark brown or black margin around socket of caudal spine forming an area about twice as high as maximum width of spine; white band at base of caudal fin usually distinct; anterior gill rakers 21 to 25; posterior gill rakers 23 to 25. (Indo-West-Pacific) . . . . . **mata**

KEY TO THE SPECIES OF *Acanthurus* OF THE ATLANTIC OCEAN

1a. Body very pale with 6 vertical black bars, the first passing through eye, the last dorsally on caudal peduncle; anal soft rays 19 to 21; dorsal soft rays 22 to 24. (Indo-Pacific, one record from West Africa) . . . . . **triostegus**

1b. Body not very pale with 6 vertical black bars; anal soft rays 22 to 26; dorsal soft rays 24 to 28 . . . . . **2**

2a. A very large pale (yellow or orange in life) spot on caudal peduncle with caudal spine in center. (West Africa) . . . . . **monroviae**

2b. No large pale spot on caudal peduncle. **3**

3a. Anal soft rays 24 to 26; dorsal soft rays 26 to 28 (usually 27); body depth about 1.7 in standard length; no narrow dark area around caudal spine; sheath of caudal spine pale; body purplish in life with conspicuous lengthwise lines (in young bright yellow without lines); anterior gill rakers 13 to 14 . . . . . **coeruleus**

3b. Anal soft rays 21 to 23; dorsal soft rays 23 to 26 (rarely 26); body depth about 2 in standard length; a narrow dark area (blue in life) around caudal spine; sheath of caudal spine dusky; body light to dark brown in life with or without faint narrow lengthwise lines; anterior gill rakers 16 to 19 . . . . . **4**

4a. Eight to 12 dark brown vertical bars on side of body; caudal fin emarginate (nearly truncate in young), caudal concavity contained about 14 to 18 times in standard length; caudal fin without a definite white posterior margin; outer ⅓ of pectoral fin pale in adults; no fine lengthwise lines on body; posterior gill rakers 15 to 18 . . . . . **chirurgus**

4b. No dark brown vertical bars on side of body; caudal fin lunate, caudal concavity contained about 5 to 12 times in standard length; caudal fin with a whitish posterior margin, broadest centrally (about ¼ to ⅓ pupil diameter in width in adults, greater in young); outer ⅓ of pectoral fin not distinctly paler than rest of fin; fine lengthwise lines on body (which usually fade in preservative); posterior gill rakers 22 to 24 . . . . . **bahianus**

Acanthurus triostegus (Linnaeus)
Figs. 1*a*, 2*a*, 3, 4

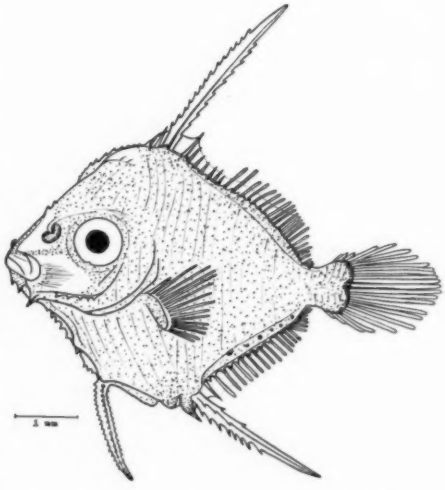


FIG. 3. Postlarval *Acanthurus triostegus sandvicensis*. Drawn with the aid of a camera lucida by Helen A. Randall (specimen taken in a plankton tow, offshore, Hawaiian Islands).

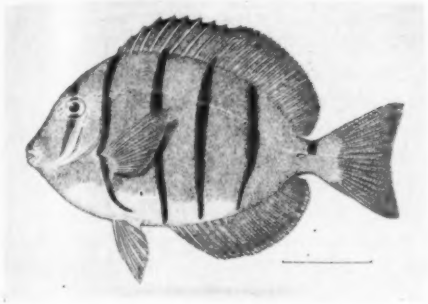


FIG. 4. *Acanthurus triostegus sandvicensis* (after Jordan and Evermann, 1905, retouched).

Chaetodon triostegus Linnaeus (1758: 274) (Indies).

Harpurus fasciatus Forster (1788) (reference after Jordan 1917).

Acanthurus Triostegus Bloch and Schneider (1801: xxxviii, 215) (Indian and Pacific Oceans).

Acanthurus zebra Lacépède (1802: 546) (Pacific Ocean and East Indies).

Chaetodon couaga Lacépède (1802: 726, 727, pl. 6, middle fig.).

Teuthis australis Gray (1827: 435) (Australia).

Acanthurus hirudo Bennett, J. W. (1828: pl. 11) (Ceylon).

Acanthurus triostegus Cuvier and Valenciennes (1835: 197) (Mauritius, Seychelles, Marianas, New Zealand, Oualan, Society Islands, and Hawaiian Islands); Bleeker (1850*a:* 13) (Batavia, Java); Günther (1861: 327) (East Indies, New Hebrides, Mauritius, New Zealand, west coast of Australia, and Hawaiian Islands); Playfair *in* Playfair and Günther (1866: 56) (Zanzibar); Günther (1873: 108) (Indian Ocean and Polynesia); Day (1876: 204, pl. 48, fig. 2) (seas of India); Macleay (1881: 527) (west coast of Australia); Steindachner (1882: 54) (Congo Coast, West Africa); Hilgendorf (1883: 43); Day (1889: 139, fig. 54); Waite (1894: 217) (Maroubra, New South Wales); Waite (1897: 187) (Funafuti, Ellice Islands); Weber (1913: 316) (East Indies); Herre (1927: 407, pl. 1, fig. 1) (Philippine Islands and Guam); Herre (1936: 240) (Cocos Island off Costa Rica, Marquesas Islands, Tuamotu Archipelago, Tahiti, Fiji Islands, and New Hebrides); Brock (1943: 130) (Tres Marias Islands, Mexico); Schultz (1943: 162) (Phoenix and Samoa Islands); Smith (1949: 240, pl. 33, no. 608) (east coast of Africa south to Zululand); de Beaufort (1951: 144) (East Indies); Harry (1953: 146) (Raroia, Tuamotu Archipelago).

Acanthurus triostegos Swainson (1839: 255) (error for *triostegus*).

Acanthurus Subarmatus Bennett, F. D. (1840: 278, fig.) (Society Islands).

Acanthurus pentazona Bleeker (1850*a:* 4, 13) (Batavia, Java); Bleeker (1850*b:* 107) (Batavia, Java); Günther (1861: 329).

Rhombotides triostegus Bleeker (1863*b:* 235) (Ternate, East Indies).

Rhombotides pentazona Bleeker (1865: 288) (Ambon, East Indies).

Acanthurus triostegus var. *sandvicensis* Streets (1877: 67) (Honolulu).

Acanthurus zebra DeVis [not of Lacépède] (1883: 447) (Duke of York Group = Tokelau Islands).

Teuthis triostegus Jordan and Evermann (1898: 1690) (Clarion and Socorro Islands, western Mexico); Seale (1901: 108) (Guam); Jordan and Evermann (1902: 357) (Kotosho Island, Formosa); Jordan and Fowler (1902: 552) (Okinawa); Kendall and Goldsborough (1911: 309) (Tuamotu Archipelago and Marshall Islands); Kendall and Radcliffe (1912: 144) (Manga Reva); Barnard (1927: 778, pl. 31, fig. 5) (Natal coast, Africa); Marshall, T. C. (1941: 62) (Moreton Bay and Townsville, Queensland); Fowler (1944*b:* 172) (New Hebrides); Fowler (1945: 66) (Saipan).

Teuthis elegans Garman (1899: 70, pl. L, fig. 2) (Cocos Island off Costa Rica).

Teuthis sandvicensis Jenkins (1903: 479) (Hawaiian Islands); Snyder (1904: 533) (Hawaiian Islands); Fowler (1941: 257) (Oahu); Fowler (1949: 104).

Hepatus sandvicensis Jordan and Evermann (1905: 394, fig. 172) (Hawaiian Islands); Jordan and Seale (1906: 354) (Hawaii).

Hepatus triostegus Snodgrass and Heller (1905: 403) (Revillagigedo Islands and Cocos Island); Jordan and Seale (1906: 354) (Samoa); Steindachner (1906: 1392) (Samoa Islands); Ogilby (1916: 184) (coast of Queensland); Fowler and Silvester (1922: 124) (Samoa); Fowler and Ball (1925: 19) (Laysan, Lisiansky, French Frigate Shoals, and Necker Island in the Hawaiian Archipelago, Johnston Island, and Wake Island); Fowler (1928: 264, pl. 31, fig. A) (Indo-Pacific); Fowler and Bean (1929: 249) (Indo-Pacific); Fowler (1932: 10) (Marquesas Islands); Seale (1935: 364) (Solomon Islands); Fowler (1938: 173, 184) (Bora Bora and Tongareva); Pietschmann (1938: 26, pl. 4) (Molokai and Pearl and Hermes Reef, Hawaiian Archipelago); Schmidt and Schultz (1940: 8) (Clipperton Island); Hiyama (1943: 95, pl. 20, fig. 57) (Marshall Islands); Aoyagi (1943: 216, pl. 6, fig. 16, teeth only) (Riu Kiu Islands); Kamohara (1954: 52) (Tokara Islands, southern Japan).

Acanthurus sandvicensis Jordan and Jordan (1922: 66) (Hawaiian Islands); Schultz and Woods (1948: 248, fig. 1, A) (Hawaiian Islands and Johnston Island).

Teuthis troughtoni Whitley (1928: 233, pl. 16, fig. 1) (Vanikoro, Santa Cruz Islands); Whitley and Colefax (1938: 294, fig. 3) (Nauru Island and Ocean Island); Fowler (1946: 197) (Riu Kiu Islands).

Acanthurus triastegus Borodin (1932: 87) (Samoa, Bora Bora, and Raiatea) (error for *triostegus*).

Acanthurus triostegus triostegus Schultz and Woods (1948: 249, fig. 1, B) (Indo-Pacific); Schultz and Woods *in* Schultz *et al.* (1953: 624, fig. 90, b, d, e, pl. 63, A, B, C, pl. 64, A, B, C) (Marshall and Mariana Islands).

Acanthurus triostegus marquesensis Schultz and Woods (1948: 250, fig. 1, C, F) (Marquesas Islands).

Dorsal rays IX, 22 to 24 (except in the Hawaiian Islands where the soft rays range to 26); anal rays III, 19 to 22; pectoral rays 14 to 16; anterior gill rakers of eight specimens from the Marshall Islands 19 to 22; posterior gill rakers 20 to 24; anterior gill rakers of eight specimens from the Hawaiian Islands 18 to 22; posterior gill rakers 19 to 22; a 54 mm. specimen has 12 upper and 14 lower teeth; a 134 mm. specimen has 14 upper and 16 lower teeth; a 158 mm. specimen has 16 upper and 18 lower teeth.

Very rarely specimens were found with VIII dorsal spines, but these could be recognized as abnormalities. The specimen reported with VIII dorsal spines from Tahiti by Schultz and Woods (1948: 250), for example, has a broad gap between its seventh and eighth spines.

Color (in life) light olivaceous gray, shading to white ventrally, with six narrow vertical black bars on head and body, the first running through eye, the second from origin of dorsal fin to base of pectoral fin, and the last dorsally on caudal peduncle; fins olivaceous gray except for margins of anal and pelvic fins which are white. Often there is a sharp demarcation between the gray color of about the upper five-sixths of the body and the pure white lower sixth, and there may be a narrow irregular dark line dividing these two colors. Schultz and Woods (1948: 248) attribute this line and the abrupt transition to white to breeding coloration. I am unable to confirm this finding, for I have observed numerous specimens with the gonads only slightly developed which exhibit this color pattern.

It was noted that specimens of *A. triostegus* from coral atolls or low-lying coral islands had narrower vertical bars on the side of the body than specimens from high islands. In 20 specimens 110 mm. or more in standard length from low islands (10 of which were collected from Midway, Laysan, French Frigate Shoal, and Johnston Island) the width of the central bar of the body (as measured midlaterally) is contained 3.3 to 8.2 times

in the greatest diameter of the eye; the mean is 5.27. The width of the bar into the eye in 20 specimens of comparable size from high islands (including the Hawaiian Islands) is 1.7 to 3.9 with a mean of 2.65. Seven specimens from a tidal pond on the island of Hawaii were strongly melanistic, and the bar width was contained in the eye diameter 1.25 to 1.8 times with a mean of 1.43. The water in this pond was clear, and the bottom was black basalt with no coral and little algae. Around coral islands the bottom is notable for being light in color. The littoral area of volcanic islands is considerably darker, in general, due to the dark brown to black color of basalt. The above mentioned tidal pond on Hawaii is unusually dark. It is therefore believed that the width of the black bars of *A. triostegus* is correlated with the degree of darkness of the substrate. This is in agreement with the well-known phenomenon of increased production of melanophores from a dark background (Breder and Rasquin, 1952: 19).

Schultz and Woods (1953: pl. 64, A, B, C) have photographs of the postacronurus and juvenile stages of *A. triostegus*.

The 5.5 mm. postlarval specimen (Fig. 3) of *A. triostegus* was taken in a plankton tow with a 1 meter net offshore from the Hawaiian Islands by personnel of the Pacific Oceanic Fishery Investigations.

Streets (1877: 67) first called attention to the differences in color between *A. triostegus* in the Hawaiian Islands and elsewhere in its range; he designated the Hawaiian form as variety *sandvicensis*. It has an elongate black streak at the base of the pectoral fin, a vertical black bar dorsally on the caudal peduncle which reaches almost to the mid-lateral line but usually has no black spot on the peduncle below this bar; there is no definite black line mid-dorsally on the head. From the rest of its range specimens have a single black spot, two black spots, or a short bar at the pectoral base; the vertical black bar on the caudal peduncle is usually more restricted to the dorsal part and there is a black spot or short bar ventrally on the peduncle; a median black line is usually evident on the head.

Schultz and Woods (1948: fig. 1) diagrammed the different color marks at the base of the pectoral fin of *A. triostegus* and tabulated the dorsal, anal, and pectoral fin ray counts of samples from a number of localities. They demonstrated the higher fin ray counts of the species in Hawaii; however they pointed out the possibility that cooler water in the Hawaiian Islands may be the cause of these higher counts. Nevertheless, these authors (and others) regarded the Hawaiian form as a full species, *Acanthurus sandvicensis*. In view of the marked geographical separation of the Hawaiian chain from other major island groups, at least slight differences are to be expected in Hawaiian populations of reef fishes. Since there is no possibility of readily testing whether Hawaiian stocks will freely interbreed with those of other areas, the task of making inferences of degree of interfertility from the observed morphological differences must be made. In my opinion the differences of *A. triostegus* in the Hawaiian Islands are not of sufficient magnitude to warrant their recognition as a basis of a species. Because of the frequent use of the name *sandvicensis*, however, I prefer to retain this as a subspecific designation for the species in Hawaii.

I have made dorsal and anal fin ray counts of *A. triostegus* from various localities (Table 2) in order to note variation from area to area and in the hope of shedding light on the question of whether water temperature has any effect on the number of fin rays. Unfortunately the number of specimens are too few in some important localities to be certain whether the apparent differences are real or due to chance. Other difficulties bear mentioning. Cooler temperatures, when correlated with high fin ray counts, might seem to be the cause of the high counts; however these might be a manifestation of the differentiation of populations in different areas. Unless counts are made from small juveniles from

such regions, the temperature at which the number of fin rays was fixed during development could not be estimated with any degree of assurance. Even more disturbing is the problem of fin ray counts made from specimens from colder areas in the path of currents from warm regions. If the counts were made from individuals of a resident population, they would reflect possible temperature effects of the area. If, however, the counts were made from fish carried as larvae from a warmer area, such an interpretation would be erroneous. The duration of the planktonic larval life of *A. triostegus* in the Hawaiian Islands has been estimated as two and one-half months (Randall, MS). Larvae of *A. triostegus* could float from the Philippines to Japan in about half this time (computed from current velocities given by Sverdrup, Johnson, and Fleming, 1946: 720). Therefore, the fin ray counts of specimens from S. Africa, New South Wales, Okinawa, and S. Japan are here not considered with respect to temperature effects on the number of fin rays.

Disregarding those areas in Table 2 in which a single specimen was available for fin ray counts, there remain eleven regions where average monthly sea surface temperatures (based on Hydrographic Office Pub. No. 225) may dip to 78° F. or lower at least one month of the year. These are Mauritius, Ningpo, China (the southerly current along the coast of China permits consideration of this locality but not Okinawa or S. Japan which are directly in the path of the Kuroshio), Marcus Island, Tahiti, Tuamotu Archipelago, Mangareva, possibly the Marquesas Islands, Galapagos Islands, Clarion Island, Hawaiian Archipelago, and Johnston Island. In seven of these regions (Mauritius, Marcus, and the Tuamotus excepted) the counts tend to be high; the number of specimens in the samples with 21 or more anal rays exceeds or is equal to the number with 20 rays. Four of these seven regions, Ningpo, Mangareva, Galapagos, and Clarion have a month in which the average sea surface temperature is 72° or less. With the exception of Galapagos, these are all areas in which the samples display a definite increase in fin ray counts. Although more counts are needed from these and other colder areas and more precise information on temperature, the data suggest that cool water is correlated with high dorsal and anal fin ray counts of *A. triostegus*.

The fin ray counts of specimens of *A. triostegus* from the principal Hawaiian Islands (Kauai to Hawaii) seem higher than might be expected from the annual range of average monthly sea surface temperatures (normally about 75° to 82° F. as based on U. S. Coast and Geodetic Survey Pub. TW-2). The dorsal rays, for example, are apparently higher than those from specimens in any other region given in Table 2 except possibly Ningpo, China. Moreover, the counts of the dorsal and anal rays of specimens from Midway to French Frigate Shoal are not higher than the Hawaiian Islands proper in spite of lower temperatures in the Leeward group (about 70° to 80° F.). This suggests that the greater number of fin rays in the Hawaiian Archipelago may be due to genetic factors; the usual temperature variation within this chain of islands may not influence the number of rays. This is consistent with the color differences of the species in the Hawaiian Islands as given above. These color differences are probably genetically governed, for no specimens from colder areas other than the Hawaiian chain were seen with typical *sandvicensis* markings.

Fowler (1927*b*: 20) noted that there was a dark streak at the base of the pectoral fin of specimens from Fanning Island in the Line Islands. I examined two of his specimens at the Bishop Museum. One of these, 109 mm. in standard length, has a definite 10 mm. streak in which the eye diameter is contained 1.2 times. This is only about half the length of the usual *sandvicensis* streak, however.

Other slightly streaked specimens were found among the collections from the Line Islands and the Phoenix Islands (and to a lesser extent in some juveniles from Tahiti).

The most pronounced streaks, 1.25 to 1.5 eye diameters in length, were seen on five specimens, 41 to 61 mm. in standard length, from Enderbury Atoll. These specimens were from the sample from which the high fin ray counts recorded in Table 2 were made. These counts are the highest of all the samples from warm water regions in the table. The streaked specimens did not exhibit higher numbers of dorsal or anal rays than those with typical *triostegus* coloration. The same applies to other specimens with short streaks (or elongate spots) from the Phoenix and Line Islands.

The tendency to streaking at the base of the pectoral in island groups to the south of Hawaii might somehow be due to interbreeding effects from larvae carried to these areas from the Hawaiian Islands or Johnston Island. Admittedly this is difficult to explain in terms of existing current patterns because of the strong westerly component of the equatorial currents. Transport back to the east in the counterequatorial does not appear to provide the answer, for it would seem that larvae would be carried at least to the Marshall Islands before the counterequatorial could possibly be reached; thus one would expect to find any effects of interbreeding to be most pronounced in the Marshall Islands. This, however, is not the case.

The size of the transforming acronurus larva of *A. triostegus*, again suggests genetic influence of Hawaiian populations in islands to the south. The acronurus or late postlarval form of *A. triostegus* enters tide pools to transform to the juvenile stage. Due to the accessibility of tide pools for collecting and the abundance of the species, the transforming stage often appears in museum collections. Fifty-six such specimens from the East Indies, Palaus, Marianas, and Gilbert Islands, all very warm regions of the Pacific, range in standard length from 19 to 25 mm. and have a mean length of 21.7 mm. The 42 available specimens of the transforming acronurus stage were measured from the following cooler regions of the Pacific: Ningpo, Marcus Island, Tahiti, Tuamotu Archipelago, Mangareva, Marquesas, and Clarion Island. The standard length of these range from 22.5 to 26.5 mm. with a mean of 24.8 mm. The larger average size of the acronuri developing in cooler water

TABLE 2
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus triostegus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS					ANAL SOFT RAYS			
	22	23	24	25	26	19	20	21	22
Natal, S. Africa	2	6	1				6	3	
Mauritius	7	9	2			2	11	5	
S. India	1		1				2		
Siam		1					1		
Maroubra Bay, New South Wales	1	1	1				1	2	
East Indies and Philippines	4	6				1	8	1	
Okinawa	1	6	2				4	5	
Ningpo, China (29.5° N)		3	9					7	5
S. Japan (30.4° N)		3					2	1	
Palau Islands	2	7	6				10	5	
Solomon Islands	1	1					2		
Fiji Islands		1					1		
Samoa Islands	3	16	6			1	16	8	
Gilbert Islands	9	22	2			3	19	11	
Marshall Islands	10	31	4			5	28	12	
Wake Island	3	14	2				12	7	
Marcus Island		3	1				4		
Mariana Islands	2	19	4			2	18	5	
Cook Islands		1					1		
Tubuai Islands		1					1		
Tahiti	1	12	8			1	10	10	
Tuamotu Archipelago	1	9	1				7	4	
Mangareva	1	2	2				2	1	2
Marquesas Islands	1	8	5				6	8	
Phoenix Islands									
Hull and Canton	6	35	11			1	38	13	
Enderbury	1	7	7				3	10	2
Baker Island	1	2				1	1	1	
Line Islands									
Palmyra	6	28	7			4	28	9	
Fanning		4	1				3	2	
Washington and Christmas		6					6		
Galapagos Islands	1	3					2	2	
Cocos Island (Costa Rica)	2	6	1			2	5	2	
Clipperton Island		1					1		
Clarion Island	3	6	5			2	4	8	
Gulf of California		1				1			
Hawaiian Archipelago									
Kauai to Hawaii	1	36	59	5	1		15	72	15
Midway to French Frigate Shoal	1	17	17				7	27	3
Johnston Island		5	15	3			1	18	4

is probably a temperature effect. Seventy-seven transforming specimens from the Hawaiian Islands vary from 23 to 29.5 mm. in standard length, with a mean length of 25.9 mm. This is higher than one might expect if the average postlarval size were wholly dependent on temperature. Twenty-two specimens from the Phoenix Islands vary from 23 to 27 mm. and have a mean standard length of 24.9 mm. Only two specimens were found in collections from the Line Islands; these measured 23.5 and 24 mm. in standard length. The large size in the Phoenix Islands (and possibly also in the Line Islands) is not consistent with the sea surface temperatures of these groups (in excess of 80° F. throughout the year). These islands are no more geographically isolated than most of the other islands of the Pacific where the sea surface temperatures are warm, so there is no reason to suspect any marked population differentiation.

The largest specimen of adult *Acanthurus triostegus* examined by me was one of a series of 17 caught by personnel of the Pacific Oceanic Fishery Investigations with a beach seine at Midway Island. It measured 213 mm. in standard length. Twelve others in the sample ranged from 174 to 206 mm. in standard length. Of over 5,000 adult specimens caught in traps off Oahu, the longest was 175 mm. in standard length. The colder water at Midway may be the principal basis for the larger size at this locality. In a small collection from Clarion and Socorro in the Revillagigedo Islands (Mexico) there are two large specimens measuring 187 and 188 mm. in standard length. The water around these islands is also cool. Of 905 specimens reported by Schultz and Woods (1953: 624) from the Marshall Islands and Marianas, the largest was 152 mm. The species appears to be small in other warm areas of the Pacific except the Line Islands and the Phoenix Islands where specimens as large as 189 mm. in standard length have been taken.

The range of *Acanthurus triostegus*, as is apparent from the above discussion, is very extensive. This species is in continuous distribution from East Africa to the tropical Pacific; it is one of the three species of the genus *Acanthurus* to have crossed the eastern Pacific barrier. It is recorded from the Galapagos Islands, Cocos Island off Costa Rica, and Clipperton Island, the Revillagigedo Islands, and Tres Marias Islands off the coast of Mexico. Vernon E. Brock has informed me that the species is rare at islands off the coast of Mexico. Boyd W. Walker kindly loaned a 94 mm. specimen collected by M. A. Newman and J. E. Fitch from Frailes Bay, Gulf of California. This is the first record from the coast of North America.

There is one record of *A. triostegus* from the Atlantic Ocean, that of Steindachner (1882: 54) from the Congo coast of Africa. Further records are needed to substantiate this.

Schultz and Woods (1948: 250) observed a much higher incidence of specimens of *A. triostegus* with two spots at the base of the pectoral fin than with a single spot or bar in the Marquesas Islands; these authors proposed the subspecific name *marquesensis* for the species in this group of islands.

It is interesting to note that neither this nor the Hawaiian subspecies has reached the coast and continental islands of America. Instead, the eastern Pacific form is *A. triostegus triostegus* which is found in the Line Islands and elsewhere in Oceania (except Hawaii and the Marquesas). This supports the contention of Herre (1940) that the counterequatorial current would seem to be the only possible mode of transport of Indo-West-Pacific fishes to the American coast. Jordan and Seale (1906: 354), Herre (1927: 409), and de Beaufort (1951: 147) are probably all in error in stating that the *sandvicensis* form of the species occurs at islands offshore from Mexico. All of the specimens which I have seen from such islands have a single black spot at the pectoral base, or occasionally two spots, or a short bar.

De Beaufort (1951: 147) stated that the typical form of *Acanthurus triostegus* occurs together with the subspecies *sandvicensis* in

the Hawaiian Islands. The basis for his statement is probably the information from Fowler (1928: 265) to the effect that the brown band in some specimens of the *sandvicensis* form does not continue below the pectoral base. I have never seen a specimen of *A. triostegus* from the Hawaiian Islands on which the brown streak does not continue below the base of the pectoral fin. Considerable variability may be observed in this marking, however, and it is conceivable that very rarely a specimen might be found with only a short bar at the pectoral base. Often the streak is interrupted such that a short bar at the pectoral base is separated from the larger part of the streak below. The streak may even be broken into three separate segments.

Acanthurus polyzona (Bleeker)
Fig. 5

Rhombotides polyzona Bleeker (1868*a*: 277) (Réunion); Bleeker *in* Bleeker and Pollen (1874: 44, pl. 12, fig. 2).

Acanthurus triostegus var. *polyzona* Peters (1876: 439).

Acanthurus polyzona Sauvage (1891: 519).

Dorsal rays IX, 23 to 25; anal rays III, 21 to 23; pectoral rays 16; eight or nine teeth on each side of upper jaw and nine or ten on each side of lower jaw.

Bleeker described the color in life as olivaceous on the back and olivaceous-silvery ventrally, with vertical black bars as follows: the first rostro-frontal on head (not very evident in figure), the second maxillo-ocular, the third oculo-interopercular, the fourth opercular, the next six on the body proper, and the last two on the caudal peduncle.

This species seems to be closely allied to *A. triostegus*, sharing with it the slightly emarginate caudal fin, low number of dorsal and anal fin rays, small caudal peduncle spine (as based on the figure in Bleeker and Pollen) and barred color pattern. Unlike the bars of *A. triostegus*, those of *A. polyzona* are more numerous and much broader dorsally than ventrally.

Acanthurus polyzona is apparently known only from the island of Réunion in the Indian Ocean. I have seen no specimens of this species.

Acanthurus nubilus (Fowler and Bean)
Figs. 2*b*, 6

Hepatus (*Harpurina*) *nubilus* Fowler and Bean (1929: 253, fig. 15) (Dodepo Island, Celebes).

Harpurina nubilus de Beaufort (1951: 166, fig. 27).

Dorsal rays VI, 27; anal rays III, 24; pectoral rays 16; anterior gill rakers 21; posterior gill rakers 24; 24 upper teeth; 28 lower teeth. These counts are based on the holotype, 153 mm. in standard length. Other specimens of this species reported on by Fowler and Bean were not located. These authors recorded the number of dorsal spines as VI or VII.

Mouth small, its width as measured from rictus to rictus contained 3.8 times in head

FIG. 5. *Acanthurus polyzona* (after Bleeker and Pollen, 1874).

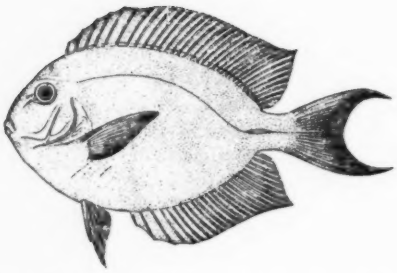


FIG. 6. *Acanthurus nubilus* (after Fowler and Bean, 1929).

length; snout short, snout length 6.8 in standard length; depth of body 1.8 in standard length; head length 4.1 in standard length; least depth of caudal peduncle 1.8 in head length; diameter of eye 3 in head length; caudal concavity 6.7 in standard length.

Color given by Fowler and Bean, for specimens other than the type, is as follows: "Nearly black, shading to brown under scales, probably dark seal brown with slaty streaks in life, of which usually 2 to each scale row. On side of head and breast brown in form of hexagonal spots in pale ground color, spots size of number 6 shot. No black shoulder blotch or black spots in axils of verticals. Fins nearly black. Dorsal with oblique bars extending upward and backward, best seen in reflected light. Oblique bars very indistinct on anal. Caudal without markings. Pectoral membranes hyaline."

Color (in alcohol) of holotype uniformly brown except membranes of pectoral fin which are hyaline.

This species is known only from Buka Buka Island in the Gulf of Tomini, Celebes, and Dodepo Island, Celebes.

A. nubilus is related to *A. thompsoni* and *A. bleekeri*. These three species of *Acanthurus* are distinctive in having small mouths, small teeth, and a moderately large eye which is set more toward the center of the head than other species in the genus.

Were it not for *A. thompsoni* and *A. bleekeri*, *A. nubilus* would probably best be placed by itself in the genus *Harpurina* because of the above characteristics and its VI or VII dorsal spines. The former species possess the usual IX dorsal spines and serve to connect *A. nubilus* with more typical *Acanthurus*.

Acanthurus bleekeri Günther
Figs. 2*c*, 7

Acanthurus mata. Bleeker (*non* Cuvier and Valenciennes) (1854*b:* 432) (Java); Aoyagi (1943: 206, pl. 4, fig. 9, teeth only).

Acanthurus bleekeri Günther (1861: 335) (after Bleeker); Herre (1927: 423, pl. 14, fig. 2) (Philippine Islands); de Beaufort (1951: 162) (East Indies); Schultz and Woods *in* Schultz *et al.* (1953: 636) (Rongelap Atoll, Marshall Islands).

Rhombotides Bleekeri Bleeker (1863*a:* 153) (Halmahera, East Indies).

Acanthurus Bleekeri Klunzinger (1871: 509) (Red Sea).

Acanthurus aurolineatus Day (1876: 204, pl. 48, fig. 3) (Coromandel coast of India); Day (1889: 139).

Acanthurus (*Rhombotides*) *Bleekeri* Klunzinger (1884: 85) (Red Sea).

Harpurus gnophodes Fowler (1904: 544, pl. 22, upper fig.) (Padang, Sumatra).

Teuthis mata. Kendall and Goldsborough (1911: 310) (Tuamotu Archipelago).

Acanthurus Güntheri Weber (1913: 317) (Ambon, East Indies).

Hepatus weberi Ahl (1923: 317) (new name for *Acanthurus Güntheri* Weber).

Hepatus bleekeri Fowler (1928: 270) (Sumatra and Fakarava, Tuamotu Archipelago); Fowler and Bean (1929: 220) (Philippine Islands and East Indies); Hiyama (1943: 94, pl. 19, fig. 54).

Teuthis bleekeri Fowler (1949: 102).

Acanthurus weberi de Beaufort (1951: 163) (East Indies).

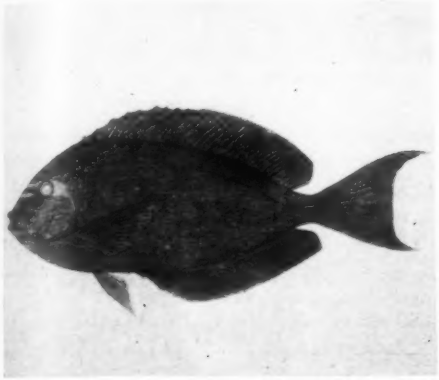


FIG. 7. *Acanthurus bleekeri* (after Hiyama, 1943).

Dorsal rays IX, 24 to 26; anal rays III, 23 or 24; pectoral rays 16 or 17; (usually 17); anterior gill rakers 13 to 15 and posterior gill rakers 13 to 15 (gill raker counts from Philippine specimens); a 71 mm. specimen has 14 upper and 16 lower teeth; a 146 mm. specimen has 18 upper and 22 lower teeth; a 200 mm. specimen has 22 upper and 24 lower teeth; a 283 mm. specimen has 24 upper and 26 lower teeth.

TABLE 3

VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus bleekeri* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS	
	24	25	26	23	24
Delagoa Bay, S. Africa		1			1
East Indies		4			4
Philippine Islands	2	5	4	2	9
Tuamotu Archipelago		1			1
Marshall Islands			1		1

Mouth small, its width from rictus to rictus contained 4.7 to 5 in head length; snout short, its length 6.6 to 6.9 in standard length; relative body depth decreasing with size from 2.1 in standard length in 118 mm. specimen to 2.5 in 283 mm. specimen; forehead sloping, the angle between a vertical at the mouth and the anterior profile of the head about 45°; length of head 3.6 to 3.7 in standard length; diameter of eye 3.2 to 4.5 in head length in specimens over a range in standard length of 118 to 283 mm.; caudal concavity about 6.5 to 8 in standard length (9 in a 71 mm. specimen); least depth of caudal peduncle 10 to 12 in standard length. This species has a narrower caudal peduncle than all other species of *Acanthurus* (in which the least depth is contained 7.7 to 9.5 times in the standard length). The stomach is large, U-shaped, with about nine rows of very large, thorn-like papillae on the inner surface.

Color (in alcohol) brown with fairly straight lengthwise pale bluish gray lines on the side of the body (28 in a specimen 200 mm. in standard length, each line about one-third as broad as the brown interspaces); head with similar, though slightly more irregular, lines (eight between eye and lower limb of preopercle in the 200 mm. specimen); opercular membranes dark brown; sheath of caudal spine blackish brown and edge of socket dark brown; all fins brown, the dorsal with a dark brown line at the base which becomes broader posteriorly, and the dorsal and the anal with faint longitudinal banding.

Life colors from Hiyama's plate (herein reproduced in black and white as Fig. 7) dark brown with lengthwise blue lines on head and body, a yellow area behind eye, and two yellow bands extending anterior from eye, one from the upper edge and one from the lower.

J. L. B. Smith kindly loaned a specimen identified in his *The sea fishes of southern Africa* (1949: 240, pl. 33, no. 609) as *Acanthurus lineolatus*. The specimen is 71 mm. in standard length and was collected in Delagoa Bay. The species figured by Smith appears to be *A. mata*, however, the specimen turned out to be *A. bleekeri*, hitherto unrecorded from southern Africa. It has been returned to Dr. Smith.

Acanthurus bleekeri is an Indo-West-Pacific species. It is not recorded from the Hawaiian Islands and is not commonly taken from the rest of the tropical Pacific.

Acanthurus thompsoni (Fowler)
Figs. 2*d*, 8

Hepatus thompsoni Fowler (1923: 386) (Honolulu); Fowler and Ball (1925: 19) (Wake Island); Fowler (1928: 268, fig. 49); Fowler (1938: 231) (Honolulu).

Acanthurus philippinus Herre (1927: 434, pl. 5, fig. 1) (Calapan, Mindoro, Philippine Islands); Schultz and Woods *in* Schultz *et al.* (1953: 637) (Rongelap, Marshall Islands); de Beaufort (1951: 161).

Hepatus philippinus Fowler and Bean (1929: 215, fig. 11) (Philippine Islands and East Indies); Kamohara (1952: 8) (Okinoshima, Province of Tosa, Japan).

Teuthis thompsoni Fowler (1949: 102).

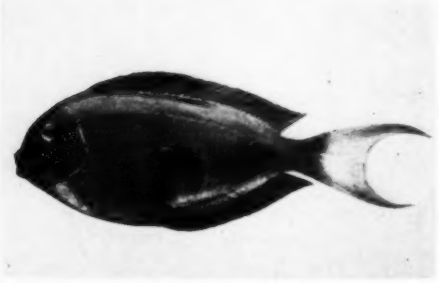


FIG. 8. *Acanthurus thompsoni.* 138 mm. specimen, Gilbert Islands. From a Kodachrome transparency by the author.

Dorsal rays IX, 23 to 26; anal rays III, 23 to 26; pectoral rays 17; anterior gill rakers of two Philippine and one Marshall Islands specimens 15 to 16; posterior gill rakers 14 to 15; anterior gill rakers of one Hawaiian Islands specimen 18; posterior gill rakers 16; a 93 mm. specimen has 20 upper and 24 lower teeth; a 138 mm. specimen has 21 lower and 24 upper teeth.

TABLE 4
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus thompsoni* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS			
	23	24	25	26	23	24	25	26
East Indies		1		1		1		1
Philippine Islands	2	2	1		1	3	1	
Marshall Islands			1				1	
Gilbert Islands			1			1		
Society Islands			1		1			
Hawaiian Islands		1		2		2		1

Mouth small, its width from rictus to rictus contained about 4 times in head length; snout very short, its length 7.9 to 8.2 in standard length; body depth about 2.3 in standard length; head length 3.7 to 4.3 in standard length; diameter of eye 3.2 to 3.5 in head length in specimens over 90 mm.; least depth of caudal peduncle 2.2 to 2.5 in head length; caudal concavity about 5 in standard length.

Color (in alcohol) brown with pale yellowish brown caudal fin (except specimens from the Hawaiian Islands in which the caudal fin is as dark as the body); a small dark brown spot just below and adjacent to axil of pectoral fin (this spot not as prominent as Fowler figured it and is difficult to see in dark specimens); about six dark bands may be visible running lengthwise in posterior part of soft dorsal fin and about five in the anal fin, although in many specimens these have faded.

Herre (1927: 434) stated that the pale caudal fin of his Philippine specimens was evidently yellow in life; however, the single specimen which I collected in the Gilbert Islands had a snow white caudal fin (which became dusky white immediately following death).

A 134 mm. specimen speared by me at a depth of 90 feet in Kealakekua Bay, Hawaii, was olive drab with brown fins; the dorsal and anal fins had a narrow blue-black margin,

and there were two to three narrow longitudinal yellow-brown lines in the outer part of these fins; the pelvic fins showed brownish yellow patches distally; the head had a reticulation of purplish yellow and brownish yellow lines. A 49 mm. juvenile specimen (U.S.N.M. No. 167250) was taken in the same locality and at the same depth. It was apparent from the scale structure and the dentition that it had only recently transformed from the acronurus stage. It was purplish blue with black longitudinal lines on the side of the body; the pectoral was yellowish with a black line at the top; there was a small black spot at the axil of the dorsal fin; however none was visible at the lower part of the axil of the pectoral fin.

I examined the holotype (Bernice P. Bishop Mus. No. 3394) and compared it with the specimen from the Gilbert Islands. Apart from the color of the caudal fin, no differences could be observed.

The largest specimen seen by me is the holotype. It is 155 mm. in standard length.

Schultz and Woods (1953: 637) stated that the species was observed swimming in a large school in the Rongelap lagoon about coral heads at depths of more than 10 feet. I saw only two solitary individuals at Onotoa Atoll in the Gilbert Islands; these occurred at a depth of from 40 to 50 feet on the coralliferous terrace of the outer reef. The adult which was collected in Hawaii was one of a group of about eight or ten individuals that tended to stay in the same general region of the reef. They were seen several times swimming slowly, about 10 to 20 feet off the coral-covered bottom. Upon my approach they swam almost straight down. Underwater some appeared dark gray, almost black, and others were light blue.

Acanthurus thompsoni occurs in the East Indies, Philippines, Japan, and Oceania. In general, it is not a common species.

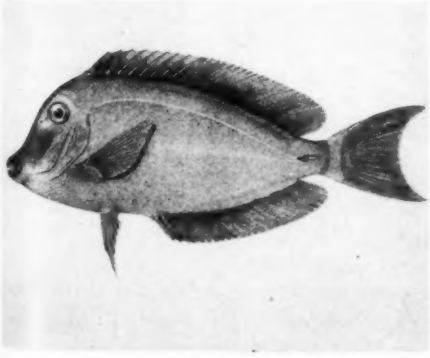


FIG. 9. *Acanthurus mindorensis* (after Herre, 1927).

Acanthurus mindorensis Herre
Fig. 9

Acanthurus mindorensis Herre (1927: 433, pl. 4, fig. 2) (Calapan, Mindoro, Philippine Islands).

Hepatus mindorensis Fowler and Bean (1929: 213).

The following is from Herre's description: dorsal rays IX, 26; anal rays III, 23; origin of mouth low on head; jaws protuberant; length of snout 1.25 in length of head (taken from figure); length of head 3.4 in total length; depth at origin of pelvics 2.3 in length; eye 4.16 in head length; interorbital gently rounded, 2.94 in head and nearly thrice eye (one of the last two proportional measurements, probably the latter, is an error); caudal spine slender, its length equal to diameter of eye; depth of caudal peduncle 2.77 in head; caudal fin moderately concave, caudal concavity 11 in standard length (from figure); pectoral fin 1.16 in head; pelvic fin 0.1 as long as head. The type, a 170 mm. specimen, had eight broad denticulate teeth on each side of the upper jaw and eight or nine on each side of the lower jaw. The denticulations on the lower teeth were more confined to the ends of these teeth than were those on the upper teeth. The color (in alcohol) was black,

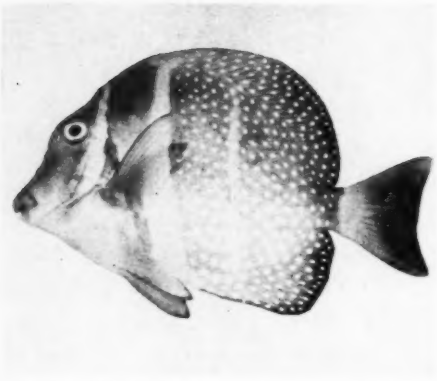


FIG. 10. *Acanthurus guttatus*. 118 mm. specimen, Gilbert Islands. From a Kodachrome transparency by the author.

sides of head and breast blackish brown; a deep brown ring at base of caudal; all fins black.

Herre has informed me that the type of this species was destroyed in Manila during World War II. To my knowledge there are no other specimens in existence.

There are two important differences between Herre's description and his figure, and at the present time there is no way to reconcile these. He described the species as having IX dorsal spines, the first one longer than in most species and not concealed. The figure shows X dorsal spines, the first smaller than that as seen on most of his figures of other species of *Acanthurus*. The deep brown ring at the base of the caudal fin is not apparent in the figure. Instead the base of the caudal fin has a pale band.

The most distinctive feature of this species is the peculiar shape of the head.

Acanthurus guttatus Bloch and Schneider
Figs. 1*j*, 2*e*, 10

Acanthurus Guttatus Bloch and Schneider (1801: xxxviii, 215) (Tahiti).

Acanthurus guttatus Cuvier and Valenciennes (1835: 195) (Tonga Islands and Mauritius); Günther (1861: 329) (Tahiti, New Hebrides, and Mauritius); Günther (1873: 109, pl. 69, fig. A) (Indo-Pacific); Waite (1897: 188) (Funafuti, Ellice Islands); Jordan and Jordan (1922: 66) (Hawaiian Islands); Schultz (1943: 163) (Phoenix and Samoa Islands); de Beaufort (1951: 142) (Sumatra); Schultz and Woods *in* Schultz *et al.* (1953: 631, pl. 66, fig. A) (Marshall and Mariana Islands); Harry (1953: 146) (Raroia, Tuamotu Archipelago).

Harpurus guttatus Forster (1844: 218) (Tahiti).

Rhombotides guttatus Bleeker *in* Bleeker and Pollen (1874: 96) (Réunion and Mauritius).

Zabrasoma guttatus Seale (1901: 110) (Guam).

Teuthis guttatus Jenkins (1903: 479) (Honolulu); Kendall and Goldsborough (1911: 310) (Gilbert Islands and Tuamotu Archipelago); Fowler (1949: 103) (Baker Island).

Hepatus guttatus Jordan and Evermann (1905: 392, fig. 70) (Honolulu); Jordan and Seale (1906: 354) (Samoa); Fowler and Bean (1929: 248) (Philippine Islands, Samoa, Gilbert Islands, and Mauritius); Fowler (1938: 184) (Tongareva).

Teuthis fuliginosus. Whitley and Colefax (1938: 294, pl. 14, fig. 4) (Nauru Island).

Dorsal rays IX, 27 to 30; anal rays III, 23 to 26; pectoral rays 15 to 17; anterior gill rakers 21 to 24; posterior gill rakers 19 to 23 (gill raker counts based on specimens from Samoa); a 43 mm. specimen has eight upper and eight lower teeth; an 85 mm. specimen has ten upper and ten lower teeth; a 152 mm. specimen has 12 upper and 12 lower teeth; a 187 mm. specimen has 12 upper and 14 lower teeth.

Body depth great, 1.5 to 1.6 in standard length; caudal fin slightly emarginate, caudal concavity contained about 14 to 17 times in standard length. Length of pectoral fin about 2.7 in standard length.

Color (in alcohol) brown with many small round or elliptical white spots (usually bordered with dark brown) on posterior half of body and dorsal and anal fins, and three ver-

tical white bars, the first on head just behind eye, the second running from base of fourth dorsal spine to anus, and the third (about one-third as broad) from base of fifth or sixth dorsal soft rays to the second or third anal soft rays; pectoral dusky yellow; pelvics light brown; caudal fin with basal half light brown, outer portion brown.

In life the pelvic fins are bright yellow.

Acanthurus guttatus is characteristic of turbulent water in shallow reef areas. In atolls it is commonly found schooling in surge channels.

The postacronurus may appear in tide pools. Three such specimens (Fig. 1*j*) vary in standard length from 33 to 36 mm.

The largest adult specimen seen by me was 228 mm. in standard length from the Hawaiian Islands.

De Beaufort (1951: 137) is probably in error in considering *Teuthis fuliginosus* Whitley and Colefax a synonym of *Acanthurus fuscus* Steindachner (the latter being a synonym of *Acanthurus pyroferus* Kittlitz). The specimen in Whitley and Colefax's photograph appears to be *A. guttatus* with the white spots barely visible.

Acanthurus guttatus would seem to stand apart from all other species of the genus primarily because of its deep body, nearly truncate caudal fin, and color pattern. *A. leucopareius*, however, appears to link this species with *A. nigrofuscus* and *A. nigroris*, for it is intermediate in body depth, caudal concavity, structure of the teeth, dorsal and anal fin ray counts, size, and color.

TABLE 5
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus guttatus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS			
	27	28	29	30	23	24	25	26
Mauritius	1	1			1	1		
Mariana Islands		2	1	1		2	1	1
Wake Island	2	7	2			7	4	
Marshall Islands	4	11	4		3	8	8	
Gilbert Islands	2	2				2	2	
Samoa Islands	1	7	4	1	2	7	3	1
Phoenix Islands		1				1		
Society Islands	2	3	2		1	2	4	
Tuamotu Archipelago		1	1				1	1
Line Islands	1	1			2			
Hawaiian Islands	1	3		1	1	2	2	

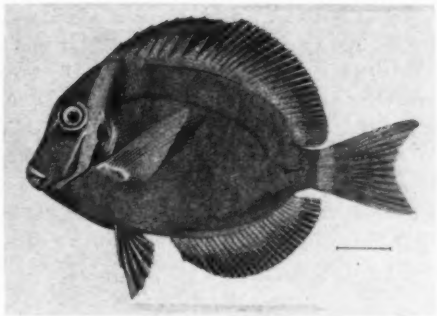


FIG. 11. *Acanthurus leucopareius* (after Jordan and Evermann, 1905).

Acanthurus leucopareius (Jenkins)
Figs. 2*f*, 11

Teuthis leucopareius Jenkins (1903: 476, fig. 23) (Honolulu).

Teuthis umbra Jenkins (1903: 477) (Honolulu); Kendall and Radcliffe (1912: 144) (Cook Bay, Easter Island).

Teuthis bishopi Bryan and Herre (1903: 134) (Marcus Island).

Hepatus leucopareius Jordan and Evermann (1905: 386, fig. 167) (Hawaiian Islands); Jordan and Seale (1906: 352); Fowler (1928: 266, pl. 30, fig. B) (Hawaiian Islands, Easter Island, and Marcus Island); Fowler and Bean (in part) (1929: 214) (Hawaiian Islands and Easter Island).

Hepatus umbra Jordan and Evermann (1905: 387, pl. 47) (Honolulu); Jordan and Seale (1906: 353).

Acanthurus leucopareius Jordan and Jordan (1922: 65) (Honolulu).

Acanthurus umbra Jordan and Jordan (in part) (1922: 65) (Hawaiian Islands).

Dorsal rays IX, 25 to 27; anal rays III, 23 to 25; pectoral rays 16; anterior gill rakers 15 to 18; posterior gill rakers 18 to 21 (raker counts from Hawaiian specimens); a 38 mm. specimen has 8 upper and 10 lower teeth; a 70 mm. specimen has 10 upper and 12 lower teeth; a 109 mm. specimen has 12 upper and 14 lower teeth; a 145 mm. specimen has 14 upper and 16 lower teeth; a 197 mm. specimen has 16 upper and 20 lower teeth.

TABLE 6

VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus leucopareius* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	25	26	27	23	24	25
Hawaiian Islands	6	15	2	3	16	4
Easter Island	1			1		
Marcus Island			1			1

Body depth 1.7 to 1.85 in standard length; caudal concavity 10 to 11 in standard length; length of pectoral fin 2.8 to 3.2 in standard length.

Color (in alcohol) brown with a dusky white band extending from origin of dorsal fin to posterior portion of opercle; posterior and adjacent to this white band a prominent dark brown band; anterior and adjacent to white band an obscure dark brown band which passes through eye; a small black spot at axil of dorsal fin (relatively large in Easter Island specimen); base of caudal fin with a distinct white band; all fins brown except pectorals which are pale with a narrow black upper margin; a faint longitudinal banding may be visible in dorsal and anal fins.

In some specimens the dark and light bands on the head are difficult to see. This is true of some freshly preserved specimens; therefore the lack of bands cannot be attributed solely to fading.

In life the white band on the head and the one at the base of the caudal fin are vivid. Faint irregular bluish lines may be seen on the body. In a 70 mm. specimen the bluish lines are fewer in number and more evident than in large specimens. On the upper one-third of the body they consist of oblique rows of discrete spots.

Transformation from the acronurus to the juvenile stage occurs at a size of about 33 to 34 mm. in standard length. The dark and light bands on the head are just making their appearance on a 40 mm. specimen.

I examined the type of *Teuthis bishopi* Bryan and Herre at the Bishop Museum (a 206 mm. specimen from Marcus Island) and the type of *Teuthis umbra* Jenkins at the United States National Museum; both are specimens of *Acanthurus leucopareius*. As the bands on the head of the type of *umbra* are very faint, it is understandable how Jenkins could have overlooked them and considered the specimen as representing a new species.

Since Jenkins, a number of authors have applied the name *umbra* to various species of *Acanthurus*. Of the specimens considered as *Acanthurus umbra* by Jordan and Jordan (1922), for example, some were *A. mata*, one was *A. xanthopterus*, and one was *A. leucopareius*. *A. mata* received the designation of *umbra* more than other species probably because of its marked pale band at the base of the caudal fin and lack of other obvious color markings.

Fowler (1928: 266) listed two "Albatross" specimens from Puako Bay, Hawaii (U.S.N.M. No. 55582) as *Hepatus leucopareius*. One of these, however, is either *Acanthurus xanthopterus* or *A. mata*. The two which he recorded as *leucopareius* from Apia, Samoa (U.S.N.M. No. 52456) are *Acanthurus nigroris*, as is the one from the Tubuai Islands (Bishop Mus. No. 750). The 105 mm. specimen from Suva, Fiji (Bishop Mus. No. 4339), which was identified as *Hepatus leucopareius*, is *Acanthurus mata*. Also misidentified by Fowler as *leucopareius* are two subadults from the New

Hebrides (Bishop Mus. No. 1028). Two specimens from Guam (Bishop Mus. No. 4261) which Fowler (1925: 12) reported as *Hepatus leucopareius* are 26 mm. acronuri which are definitely not this species.

Fowler (1930: 612) recorded *Hepatus leucopareius* from Hong Kong. I was unable to locate his specimen at the Academy of Natural Sciences of Philadelphia. Also I have not examined his specimens of *leucopareius* from the Philippines. His reference to their poor condition (1927*a:* 287) suggests that this may be a tenuous identification. A. W. Herre has written me that he has never seen *Acanthurus leucopareius* in the Philippines. The presence of the species in his checklist (1953: 536) is probably based on Fowler.

The only definite records of this species are from the Hawaiian Islands, Marcus Island, and Easter Island, all remote and widely separated areas of Oceania. If these three regions represent the total distribution, *A. leucopareius* would seem to be a relict species. It is easier to suppose that it was once in continuous distribution throughout Oceania but survives now only in these three outposts than to assume that it is endemic to one of these islands and spread to the others without becoming established in intervening areas.

This species is one of the most common of the genus in the Hawaiian Islands. It is most often seen in relatively shallow reef areas subject to some turbulence from wave action. It has been observed in schools.

Acanthurus nigroris Cuvier and Valenciennes

Figs. 1*i*, 2*g*, 12

Acanthurus nigroris Cuvier and Valenciennes (1835: 208) (Hawaii); Weber (1913: 317) (East Indies).

Acanthurus lineolatus. Bleeker (1854*a:* 101) (Banda Islands, East Indies); Günther (1873: 112, pl. 73, fig. A) (Society Islands); Steindachner (1901: 493) (Honolulu); de Beaufort (in part ?) (1951: 160) (East Indies).

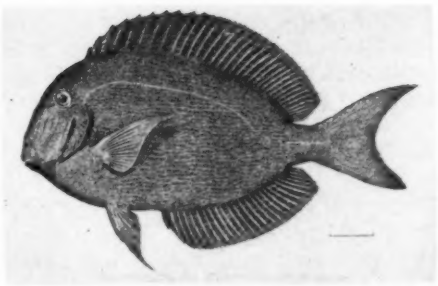


FIG. 12. *Acanthurus nigroris* (after Jordan and Evermann, 1905, retouched).

Acanthurus bipunctatus Günther (1861: 331) (China).

Acanthurus nigros Günther (1861: 332) (New Hebrides); Günther (in part) (1873: 110) (New Hebrides, Palau Islands, and Tahiti).

Rhombotides lineolatus. Bleeker (1865: 288) (Ambon, East Indies).

Teuthis atrimentatus Jordan and Evermann (1903: 198) (Honolulu); Jenkins (1903: 478) (Hawaiian Islands).

Teuthis striatus. Bryan and Herre (1903: 133) (Marcus Island).

Hepatus atramentatus Jordan and Evermann (1905: 393, fig. 171) (Hawaiian Islands); Jordan and Seale (1906: 352) (Samoa).

Acanthurus atramentatus Jordan and Jordan (1922: 65) (Hawaiian Islands); Herre (1927: 422, pl. 3, fig. 1) (Philippine Islands).

Hepatus elongatus. Fowler (in part) (1928: 267) (Oceania).

Hepatus lineolatus. Fowler (in part) (1928: 270) (Oceania); Fowler and Bean (in part) (1929: 228) (Philippine Islands and Hawaiian Islands); Fowler (1931: 345) (Honolulu); Fowler (1938: 232) (Honolulu).

Hepatus fuliginosus. Fowler and Bean (in part) (1929: 211) (Honolulu).

Hepatus leucopareius. Fowler and Bean (in part) (1929: 214) (Apia, Samoa).

Teuthis lineolatus. Fowler (1941: 257, fig. 9) (Honolulu); Fowler (1949: 103) (Howland Island).

Acanthurus elongatus. Schultz (in part) (1943:

165) (Phoenix and Samoa Islands); Schultz and Woods *in* Schultz *et al.* (in part) (1953: 634, pl. 62, fig. C) (Marshall and Mariana Islands).

Dorsal rays IX, 23 to 27; anal rays III, 22 to 25 (one specimen from the Hawaiian Islands has IV anal spines); pectoral rays 15 or 16; a 61 mm. specimen has 10 upper and 12 lower teeth; a 96 mm. specimen has 12 upper and 14 lower teeth; a 159 mm. specimen has 12 upper and 14 lower teeth. See Table 9 for gill raker counts.

TABLE 7

VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus nigroris* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS					ANAL SOFT RAYS			
	23	24	25	26	27	22	23	24	25
Marshall Islands		21	18			13	19	7	
Gilbert Islands		2	1			2	1		
Rose Island, Samoa Is.		4	7				8	3	
Swains Island, Samoa Is.	1	3	3			2	5		
Phoenix Islands	2	12	7	1		3	17	2	
Line Islands		1	2			1	2		
Wake Island		4	7	1			10	2	
Oahu and Hawaii		1	7	20	2		4	14	12
Laysan and French Frigate Shoal			2	6			1	3	4
Johnston Island		3	8	9		1	6	10	3

Caudal concavity 5.8 to 10.5 in standard length (5.8 to 7.5 in specimens from the Hawaiian Islands and Johnston Island and 6.7 to 10.5 from elsewhere in the Pacific); body depth 1.8 to 2 in standard length; ends of central upper teeth rounded (Fig. 2*g*).

The largest specimen seen by me measures 204 mm. in standard length. It was collected at French Frigate Shoal.

Color (in alcohol) of Hawaiian specimens brown with irregular, lengthwise, bluish gray or dark brown lines (about one-fourth as broad as intervening brown areas) on body; about six or seven slightly irregular, narrow, dark bluish gray or dark brown lines on head running parallel to profile of snout (in some preserved specimens these lines and those on the body are very faint or imperceptible); a small black spot about the size of the pupil at the axil of both the dorsal and the anal fins; dorsal fin with about five or six lengthwise dark brown bands; anal fin with four or five similar bands; a light grayish brown band often present at base of caudal fin; posterior margin of caudal fin very narrowly pale; pectoral fin pale with narrow dark upper margin; pelvic fins brown; no narrow black margin around socket of caudal spine.

In life the bluish gray or dark brown lines on the body and head are light blue; the dark bands in the dorsal and anal fins are bluish and the intervening bands light yellowish brown; pectoral fin rays dull yellow, membranes clear; iris yellow.

Wake Island specimens, even large adults, have rows of small round blue spots on the body instead of entire or slightly broken blue lines. Specimens from elsewhere in Oceania appear to be colored much like Hawaiian examples, as indicated in the color plate in Günther (1873) of a specimen from the Society Islands (identified as *Acanthurus lineolatus*).

The number of blue lines on the body are fewer in smaller specimens. A 51 mm. juvenile from the Hawaiian Islands, for example, has only 11 lines on the body.

In this species and *Acanthurus nigrofuscus* the black spot in the axil of the dorsal fin makes its appearance before the spot in the axil of the anal fin. The dorsal spot first shows before these species complete the transformation from the acronurus to the juvenile state (which occurs at a standard length of from about 34 to 39 mm. in *A. nigroris*). The anal spot first appears on specimens of *nigroris* about 42 to 50 mm. in standard length.

A. nigrofuscus seems to be closely related to *A. nigroris*, and these two species have often been confused. As indicated in the key, they may be separated by caudal concavity, body depth, maximum size, shape of upper teeth,

size of the spot in the axil of the dorsal fin, width of the pale posterior margin of the caudal fin, presence or absence of spots on the head, and presence or absence of a dark margin around the groove of the caudal spine. In addition, the posterior tips of the dorsal and anal fins of *A. nigrofuscus* are more pointed when these fins are elevated than are the fins of *A. nigroris*. The base of the caudal fin of *A. nigrofuscus* is rarely paler than the rest of the fin or the body. The bands in the dorsal and anal fins of *A. nigrofuscus* are poorly defined and rarely persist in preserved specimens. The lips of *A. nigrofuscus* tend to be blackish while those of *A. nigroris* are usually only slightly darker than the rest of the head.

Small juveniles of these two species are difficult to distinguish, but the greater concavity of the caudal fin and larger black spot at the base of the last few dorsal and anal rays of *A. nigrofuscus* still permit separation. I am unable, however, to distinguish with assurance the acronurus or postacronurus larval forms of these species. The immediate postacronurus of Figure 1*i* from Wake Island is identified largely because of the prevalence of *A. nigroris* at this island and the apparent absence of *A. nigrofuscus* (as based on collections and observations of W. A. Gosline and the author).

The Phoenix Islands, Swains Island, and Johnston Island are other areas in the Pacific from which *A. nigroris* has been taken and *A. nigrofuscus* is as yet unknown. Forty-seven specimens of *A. nigroris* were collected by L. P. Schultz from the Phoenix Islands and Swains Island. These are not as well differentiated from *A. nigrofuscus* as specimens from other regions such as the Marshall Islands. The caudal fin is slightly more lunate, and the white posterior edge is broader; the black spots at the rear base of the dorsal and anal fins are a little larger. Forty-eight specimens of *A. nigroris* were collected by Gosline, Brock, Yamaguchi, *et al.* from Johnston Island. Also there are several specimens of this species from Johnston in the United States National Museum and the Bishop Museum. When *A. nigroris* and *A. nigrofuscus* occur together, the latter is usually more prevalent. For example, the 82 specimens of these two species collected by Schultz at Rose Island in the Samoa Islands include only eight *A. nigroris*.

The populations of *A. nigroris* from Johnston Island and the Hawaiian Islands differ significantly from those of other regions of the Pacific in having higher fin ray counts (Table 7), higher gill raker counts (Table 9), and more concave caudal fins. There appear to be slight meristic differences between the species in Johnston Island and the Hawaiian Islands.

The type of *Acanthurus nigroris* Cuvier and Valenciennes is in the Paris Museum. The type locality is Hawaii. According to L. Bertin (personal communication), the specimen is 130 mm. in standard length and has 12 upper and 12 lower teeth (Cuvier and Valenciennes recorded 12 upper and 14 lower teeth). Of the known species of Hawaiian acanthurids, this information alone narrows the possibility to three, *A. nigroris* as here defined, *A. nigrofuscus*, and *A. leucopareius*. Apparently no color markings are now evident on the specimen, but information on the shape of the caudal fin and ends of the dorsal and anal fins clearly eliminates *A. nigrofuscus*. Failure of Cuvier and Valenciennes to mention the vertical white and dark brown bands on the head, so characteristic of *A. leucopareius*, strongly favors the present use of the name *nigroris*.

Jordan and Evermann (1903) were the first to realize that the use of the name *lineolatus* for this species was an error. They proposed the name *atramentatus*. I examined their type of *Teuthis atramentatus* (= *Acanthurus nigroris*) in the United States National Museum.

Through correspondence with A. C. Wheeler of the British Museum, I was able to learn that one of the types of *Acanthurus bipunctatus* Günther is *A. nigroris* and the other is *A. nigrofuscus*. Günther also included specimens

of both of these species as types of *Acanthurus nigros*. For purposes of synonymy I designate as the lectotype of *Acanthurus bipunctatus* Günther the 126 mm. specimen (British Mus. No. 1848.3.13.215) from China. I designate as lectotype of *Acanthurus nigros* Günther the 160 mm. specimen (British Mus. No. 1861.5.31.29) from the New Hebrides. Thus both of these names become synonyms of *Acanthurus nigroris* Cuvier and Valenciennes as the species in here interpreted.

A. nigroris appears to range throughout Oceania. The species probably occurs in China, the Philippines, and the East Indies as well. I have seen no specimens from the Indo-Malayan region. Herre's (1927: 422) description of *Acanthurus atramentatus* (Jordan and Evermann) from the Philippines seems to apply to *A. nigroris;* however his figure (pl. 3, fig. 1) is suggestive of *A. nigrofuscus*. Bleeker's (1854*a:* 101) description of *Acanthurus lineolatus* (not of Cuvier and Valenciennes) from the Banda Islands, East Indies, and that of de Beaufort (1951: 160) check with *A. nigroris*. De Beaufort's reference to a lunate caudal fin and certain variability in color pattern suggests, however, that he also had some specimens of *A. nigrofuscus*.

Acanthurus nigrofuscus (Forskål)
Fig. 2*b*, Pl. 1

Chaetodon nigro-fuscus Forskål (1775: xiii, 64) (Red Sea).

Chaetodon nigrofuscus Linnaeus and Gmelin (1788: 1268).

Acanthurus rubropunctatus Rüppell (1828: 59, pl. 15, fig. 1) (Red Sea); Günther (1861: 333); Klunzinger (1871: 508) (Red Sea).

Acanthurus matoides Cuvier and Valenciennes (1835: 204) (Oualan).

? *Acanthurus lineolatus* Cuvier and Valenciennes (1835: 207) (East Indies).

Acanthurus nigro-fuscus Cuvier and Valenciennes (1835: 214) (Réunion and Red Sea).

Acanthurus rubro-punctatus Cuvier and Valenciennes (1835: 222).

Ctenodon rubropunctatus Swainson (1839: 256).

Acanthurus mata. Day (1876: 205, pl. 48, fig. 1) (seas of India).

Acanthurus (Rhombotides) nigrofuscus Klunzinger (1884: 84) (Red Sea).

Acanthurus gahm. Day (1888: 789) (*mata* of Day, 1876); Day (1889: 141).

Acanthurus bipunctatus. Steindachner (1901: 494) (Honolulu).

Teuthis bipunctatus. Jordan and Evermann (1902: 358) (Kotosho Island, Formosa); Jordan and Fowler (1902: 554) (Riu Kiu Islands and Formosa); Jenkins (1903: 479) (Honolulu).

Hepatus elongatus. Jordan and Evermann (1905: 389) (Hawaiian Islands); Jordan and Seale (1906: 352) (Samoa); Fowler (in part) (1928: 267) (Oceania); Fowler and Bean (in part) (1929: 213) (Hawaiian Islands); Fowler (1938: 230) (Honolulu); Aoyagi (1943: 208, pl. 6, fig. 18) (Riu Kiu Islands); Kamohara (1954: 52, fig. 13) (Tokara Islands, southern Japan).

Acanthurus elongatus. Jordan and Jordan (1922: 65) (Hawaiian Islands); Herre (1936: 246) (Tuamotu Archipelago and New Hebrides); Schultz (in part) (1943: 165) (Samoa Islands); Schultz and Woods *in* Schultz *et al.* (1953: 634, pl. 62, fig. D) (Marshall and Mariana Islands); Harry (1953: 148) (Raroia, Tuamotu Archipelago).

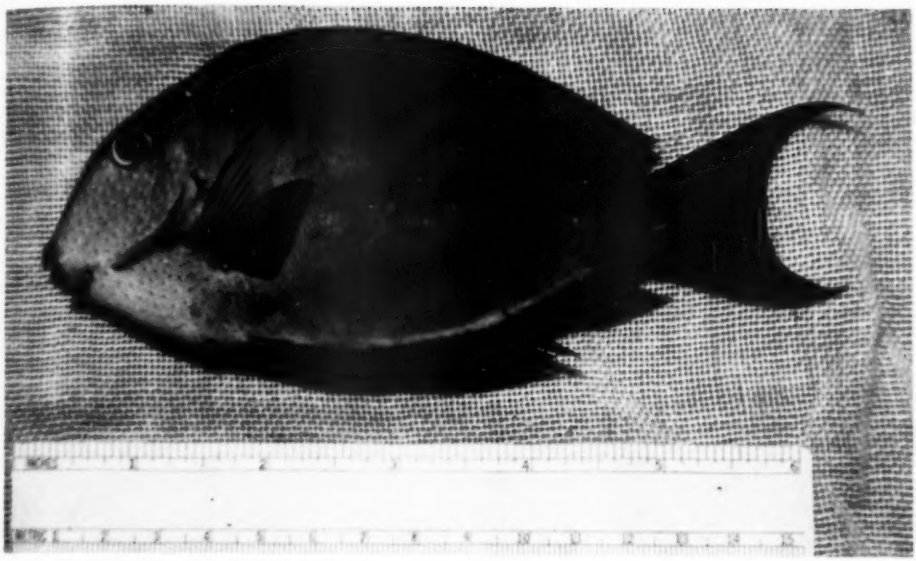
Teuthis elongatus. Barnard (1927: 778) (Natal coast, Africa).

Acanthurus marginatus. Herre (1927: 427, pl. 3, fig. 2) (Philippine Islands).

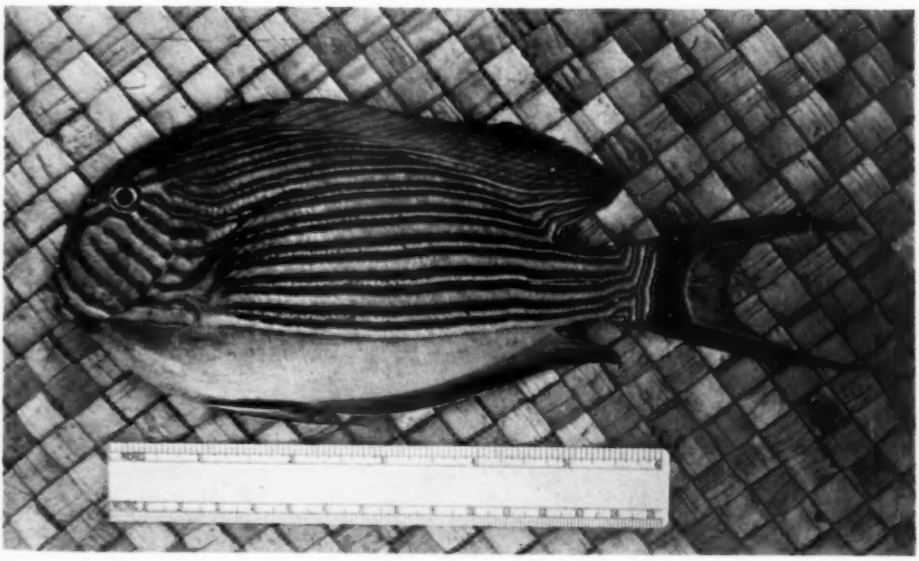
Acanthurus nigroris. Herre (1927: 428, pl. 4, fig. 1) (Philippine Islands and Guam); Schmidt (1930*b:* 103) (Riu Kiu Islands).

Hepatus fuliginosus. Fowler (in part) (1928: 266) (Oceania).

Hepatus lineolatus. Fowler (in part) (1928: 270) (Oceania); Fowler and Bean (in part) (1929: 228) (Philippine Islands, Mauritius, Samoa, and Hawaiian Islands); Pietschmann (1938: 26, pl. 2, fig. C) (Molokai, Hawaiian Islands).



Acanthurus nigrofuscus, Hawaiian Islands.



Acanthurus lineatus, Gilbert Islands.

Acanthurus flavoguttatus. Herre (1936: 245) (New Hebrides).

Hepatus lucillae Fowler (1938: 231, fig. 23) (Honolulu).

Teuthis lucillae Fowler (1941: 257) (Honolulu); Fowler (1949: 103).

Dorsal rays IX, 24 to 27; anal rays III, 22 to 24; pectoral rays 16 or 17; a 55 mm. specimen has 10 upper and 12 lower teeth; a 79 mm. specimen has 12 upper and 14 lower teeth; a 120 mm. specimen has 12 upper and 14 lower teeth; a 148 mm. specimen has 14 upper and 16 lower teeth. See Table 9 for gill raker counts.

TABLE 8
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus nigrofuscus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS		
	24	25	26	27	22	23	24
Red Sea	4				2	2	
Mauritius	1	4				2	3
East Indies		1	1			1	1
Philippine Islands	2	2	1			4	1
Okinawa		1				1	
Mariana Islands	2	8			1	6	3
Marshall Islands	15	24	2			29	12
Gilbert Islands	2		1		1	1	1
Palau Islands		2	1			1	2
Samoa Islands	14	18	7	1	1	22	17
Hawaiian Islands	6	16	4		1	9	16

Caudal fin lunate, caudal concavity 4.5 to 6 in standard length; body depth 2 to 2.3 in standard length; ends of upper teeth tend to be pointed (Fig. 2*b*).

Color (in alcohol) brown, with or without fine bluish gray longitudinal lines on body; a prominent black spot, greater in width than half the diameter of eye, in axil of dorsal fin; a slightly smaller black spot in axil of anal fin; head and chest in life with numerous small bright orange spots which may or may not persist as pale spots in preservative; caudal fin with a distinct dull white posterior border, about one-half pupil diameter in width at the center and becoming narrow out on lobes (in East Indian and Indian Ocean specimens this border is narrower); an indistinct blackish brown area submarginal to white border of caudal fin; a narrow black margin around socket of caudal spine; lips blackish brown; dorsal and anal fins with faint longitudinal banding in life which is rarely evident on preserved specimens; margin of dorsal and anal fins narrowly dark (blue in life on anal fin); pectoral fin pale with upper edge narrowly black; pelvic fins brown.

Acanthurus nigrofuscus appears to reach a larger size in the Hawaiian Islands than in the Marshall, Mariana, and Samoa Islands (island groups from which large collections of this species are available). In Hawaii the species attains a size of at least 152 mm. in standard length. Few specimens from the Marshalls, Marianas, or Samoa exceed 100 mm. in standard length. One 143-millimeter-long specimen was found in a collection from Mauritius.

Although the acronurus is difficult to separate from that of *A. nigroris*, late transforming specimens of *A. nigrofuscus* have been identified from the Hawaiian Islands and the Marshall Islands. The size at transformation in both areas is about 43 mm. A 34 mm. postacronurus from the East Indies is identified as this species.

I know of no type material of *Acanthurus nigrofuscus* (Forskål). The species was described as having a brown-black body and a caudal fin with a whitish posterior edge and lobes which are falcate and half as long as the entire fin. Although the description of *A. nigrofuscus* is brief, it fits the species as here defined better than any other known species of the genus. This is especially true when only the species of *Acanthurus* in the Red Sea and their relative abundance are considered. With the possible exception of *A. sohal* (Forskål) and *A. gahhm* (Forskål), *A. nigrofuscus* appears to be the most common species of the genus in the Red Sea. Although Forskål did not

TABLE 9
VARIATION IN GILL RAKER COUNTS OF SPECIMENS OF *Acanthurus nigroris* AND *Acanthurus nigrofuscus* FROM DIFFERENT LOCALITIES

SPECIES AND LOCALITY	ANTERIOR GILL RAKERS												POSTERIOR GILL RAKERS							
	20	21	22	23	24	25	26	27	28	29	30	31	18	19	20	21	22	23	24	25	26	27
A. nigroris																						
Marshall Islands		1	2	2	3	2									3	1	3	2	1			
Phoenix Islands		1	2	4	3	1									2	3	3	2	1			
Samoa Islands		1	2	1	3	3								1	2	2	3	2				
Wake Island			1	3	3										2	1	2	1	1			
Hawaiian Islands							1	3	3	2	1							1	3	4	2	
Johnston Island							2	2	3	2		1							2	2	4	2
A. nigrofuscus																						
Marshall Islands	2	2	5	1									2	3	3	2						
Samoa Islands	1	2	5	2	1								1	2	4	3		1				
Hawaiian Islands		2	3	3	2									3	3	3	1					

state that a black spot was present at the axil of the dorsal and anal fins, these spots could have been overlooked. Specimens of *A. nigrofuscus* in the United States National Museum recently collected from the Red Sea are sufficiently melanistic so that these spots cannot be perceived easily without holding the fish in front of a bright light.

The failure to note these spots by some authors and their observance by others has contributed to the nomenclatorial confusion of this species. More confusing is the evanescent quality of the orange spots on the head. A number of synonyms of *A. nigrofuscus* owe their origin to descriptions from fresh specimens on which the spots are the most conspicuous color feature. Preserved specimens, with these spots faint or absent, have often been listed under different names. Rüppell (1828: 59, pl. 15, fig. 1) described and figured *Acanthurus rubropunctatus* from the Red Sea. He emphasized the small red spots on the head, but did not mention black spots in the axils of the dorsal and anal fins. W. Klausewitz (personal communication) has provided additional information on the types in the Senckenberg Museum at Frankfurt. These have a black spot at the base of the last few dorsal rays and another at the base of the last few anal rays.

I have examined the holotype and paratypes of *Hepatus lucillae* Fowler at the Academy of Natural Sciences of Philadelphia. The specimens are *Acanthurus nigrofuscus*. They were considered distinctive by Fowler largely because of the bright golden spots on the head.

Herre, in his review of Philippine surgeon fishes (1927), listed this species under two names, *Acanthurus marginatus* Cuvier and Valenciennes (with whitish spots on the head) and *Acanthurus nigroris* Cuvier and Valenciennes. The former is a new name for *Acanthurus guttatus* Kittlitz. I was unable to locate Kittlitz' type; it was described as a brown fish with numerous blue spots on the head and body and is either the true *Acanthurus nigroris* or a *Ctenochaetus* (see Randall, in press, *a*). In 1936 Herre used two different names for *A. nigrofuscus;* these were *Acanthurus flavoguttatus* Kittlitz [probably = *Ctenochaetus striatus* (Quoy and Gaimard)] and *Acanthurus elongatus* (Lacépède).

The name *elongatus* has been applied to the species *Acanthurus nigrofuscus* by other authors as well. Not only is *Chaetodon elongatus* Lacépède a later name than *Chaetodon nigrofuscus* Forskål, but it was used by Lacépède for another species, probably one in the *A. xanthopterus–A. mata–A. dussumieri* complex.

L. Bertin has supplied me with sufficient

information on the type of *Acanthurus matoides* Cuvier and Valenciennes to enable me to place this name in the synonymy of *Acanthurus nigrofuscus*. The type of *A. matoides* is 120 mm. in standard length, has 12 upper and 12 lower teeth, and a caudal concavity of 23 mm. This name has been most commonly used for the species *Acanthurus xanthopterus* Cuvier and Valenciennes.

Bertin could find no type of *Acanthurus lineolatus* Cuvier and Valenciennes in the Paris Museum. The original description is too brief to permit certain identification. Mention of the shape of the caudal fin and of fine longitudinal blue lines on the body suggests that these authors had specimens of *Acanthurus nigrofuscus*.

Acanthurus lineatus (Linnaeus)
Figs. 1*e*, 2*i*, Pl. 1

Chaetodon lineatus Linnaeus (1758: 274) (Indies).

Acanthurus Lineatus Bloch and Schneider (1801: xxxviii, 214) (East Indies).

Acanthurus lineatus Lacépède (1802: 547, 550); Cuvier and Valenciennes (1835: 223) (East Indies); Bleeker (1853*a:* 263) (Sumatra); Günther (1861: 333) (East Indies and Philippine Islands); Kner (1865–67: 210) (Tahiti); Günther (1873: 111, pl. 70) (East Indies, Polynesia south of equator, and Indian Ocean); Day (1876: 203) (seas of India); Day (1889: 138); Weber (1913: 317) (East Indies); Herre (1927: 420, pl. 14, fig. 1) (Philippine Islands and Guam); Herre (1936: 242) (Bora Bora and New Hebrides); Schultz (1943: 165) (Phoenix and Samoa Islands); Smith (1949: 240, pl. 33, no. 610) (east coast of Africa south to Delagoa Bay); de Beaufort (1951: 147) (East Indies); Schultz and Woods *in* Schultz *et al.* (1953: 630) (Marshall and Mariana Islands); Harry (1953: 149) (Raroia, Tuamotu Archipelago).

Acanthurus vittatus Bennett, J. W. (1828: pl. 2) (Ceylon).

Ctenodon lineatus Swainson (1839: 256).

Harpurus lineatus Forster (1844: 216).

Rhombotides lineatus Bleeker (1863: 235) (Ternate, East Indies).

Teuthis lineatus Seale (1901: 108) (Guam); Schmidt (1930*a:* 555) (Riu Kiu Islands); Fowler (1946: 198) (Riu Kiu Islands); Fowler (1949: 102) (Jarvis Island and Howland Island).

Hepatus lineatus Jordan and Seale (1906: 351) (Samoa); Evermann and Seale (1923: 78) (Guadalcanal, Solomon Islands); Fowler (1928: 269) (Oceania); Fowler and Bean (1929: 218, fig. 12) (Philippine Islands and East Indies); Fowler (1938: 147, 202) (Tahiti and Christmas Island); Aoyagi (1943: 215, pl. 6, fig. 17) (Riu Kiu Islands).

Dorsal rays IX, 27 to 30; anal rays III, 25 to 28; pectoral rays 16; anterior gill rakers 14 to 16; posterior gill rakers 13 to 15 (raker counts from Samoan specimens); a 107 mm. specimen has 12 upper and 14 lower teeth; a 180 mm. specimen has 14 upper and 15 lower teeth.

TABLE 10
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus lineatus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS			
	27	28	29	30	25	26	27	28
Mauritius	1					1		
East Indies		1					1	
Palau Islands	1	4	2				6	1
New Hebrides	1	1			1	1		
Philippine Islands	1	1					2	
Mariana Islands	5	9	3			1	10	6
Marshall Islands	3	6				3	6	
Gilbert Islands	5	3				2	4	2
Samoa Islands	5	2	1			2	5	1
Society Islands	4	4				3	5	
Marquesas Islands				1				1

Caudal fin strongly lunate, caudal concavity contained 3.3 to 4.5 times in standard length; caudal spine long (its length about

1.9 to 2 in head length), slender, and sharp on both edges; body depth 2.1 to 3 in standard length (in specimens over 100 mm. in standard length).

Color in alcohol: lower one-fourth of body light grayish brown; upper three-fourths with alternate pale yellowish white and broad black near-longitudinal lines, each of the latter bissected with a pale bluish gray line; head with a varying pattern of curved lines similar to those on body (but with black lines narrower); dorsal fin with numerous alternating narrow dark brown and bluish gray lines; anal fin dusky yellow; both dorsal and anal fins with a narrow black margin (extreme edge pale); caudal fin dark brown with vertical dark and light lines at base and a large crescentic area in mid-posterior portion; pectoral fin pale with dusky rays; pelvic fins light yellowish brown, the outer margin black.

Fowler and Bean (1929: fig. 12) demonstrated the variability in color pattern which may be seen in Philippine specimens of this species. The two sides of the same fish may show different patterns of lines.

In addition to the blue, yellow, and black color as seen in adults, four juvenile specimens (37 to 40 mm. in standard length) from the Gilbert Islands displayed bright red color on the dorsal and anal fins (especially posteriorly) and on the caudal fin and pelvic fins.

Four specimens examined from the Marianas, Palaus, and East Indies are in the stage of transformation from the acronurus to the juvenile state at a size of from 27 to 32.5 mm. in standard length.

Museum specimens of transforming *A. nigroris* have been found misidentified as *A. lineatus*. Although both have a linear color pattern in the late acronurus (Fig. 1*e* and *i*), they may be distinguished readily.

Acanthurus lineatus is distributed from East Africa to the central Pacific. It appears to be absent from the Red Sea. It is not known from the Hawaiian Islands, Johnston Island, Wake Island, or Marcus Island (Fowler, 1928: 269, was in error in considering *Teuthis striatus* Bryan and Herre to be *A. lineatus;* the specimens are *A. nigroris*). The extensive collections of fishes from the northern Marshall Islands, which are being reported on by Schultz *et al.* (1953), include only two specimens of this species. In the Gilbert Islands, however, I found *A. lineatus* to be very common, especially in the surge channel habitat. Vernon E. Brock has informed me that the species is common at Palmyra in the Line Islands.

The colorful *A. lineatus* and *A. sohal* are well demarked from other species of *Acanthurus*. They are distinctive in the possession of dark lengthwise bands on the body, strongly lunate caudal fins, and highly developed caudal spines. In addition to being very long and sharp, the spines of these two species are peculiar in being nearly free of sheath.

Acanthurus sohal (Forskål)
Figs. 1*g*, 2*j*, 13

Chaetodon sohal Forskål (1775: xiii, 63) (Red Sea).

Chaetodon Sohar Linnaeus and Gmelin (1788: 1268) (coasts of Arabia).

Acanthurus Sohal Bloch and Schneider (1801: xxxviii, 215) (coasts of Arabia); Cuvier and Valenciennes (1835: 227) (Red Sea).

Acanthurus carinatus Bloch and Schneider (1802: 216) (Arabian Sea).

Aspisurus sohar Lacépède (1802: 556) (sea of Arabia).

Choetodon sohab Cuvier (1817: 331) (after Linnaeus and Gmelin).

Acanthurus sohal Rüppell (1828: 56, pl. 16, fig. 1) (Red Sea); Günther (1861: 334) (Red Sea); Klunzinger (1871: 507) (Red Sea).

Ctenodon Rüppelii Swainson (1839: 256, fig. 74).

Acanthurus (*Rhombotides*) *sohal* Klunzinger (1884: 83) (Red Sea).

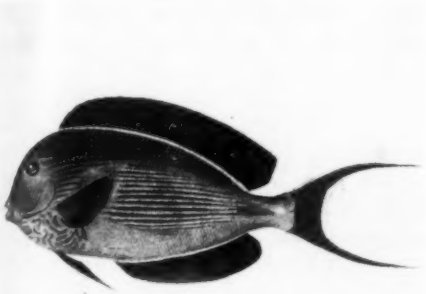


FIG. 13. *Acanthurus sohal* (after Rüppell, 1828).

Dorsal rays VIII, 30 or 31; anal rays III, 28 or 29 (usually 29); pectoral rays 17 (fin ray counts from six specimens from the Red Sea); anterior gill rakers 15 to 17; posterior gill rakers 14 or 15 (raker counts from three Red Sea specimens); an 87 mm. specimen has 12 upper and 14 lower teeth; a 130 mm. specimen has 12 upper and 16 lower teeth; a 206 mm. specimen has 14 upper and 16 lower teeth; a 270 mm. specimen has 16 upper and 18 lower teeth.

Caudal fin strongly lunate, caudal concavity contained about 3 to 4 times in standard length (in specimens over 150 mm. in standard length; an 87 mm. specimen has a caudal concavity which is contained 5 times in its standard length); caudal spine long in adults (1.9 to 2 in head length), slender, very sharp, and without a thick sheath; body depth 2 to 2.2 in standard length; diameter of eye varies from 3 in head length of 87 mm. specimen to 5 in head length of 270 mm. specimen.

Color (in alcohol) light brown with about 15 longitudinal dark brown bands (each about two to three times as broad as intervening light brown bands) on side of body above level of lower part of pectoral fin; on the back a second less conspicuous and more oblique series of bands which become relatively narrower with age; longitudinal dark lines on head dorsal to lower margin of eye; dorsal, anal, and pelvic fins brownish black (smaller specimens with lengthwise bands in dorsal fin); caudal fin black, shading to dark brown in center, with a narrow pale margin (broader in smaller specimens); pectoral fin dark brown, slightly paler in upper middle portion, with narrow pale posterior margin; caudal spine and margin of socket cream.

Color of a fresh specimen as shown in a photograph (Cousteau, 1952: 461): body below pectoral fin light tan, above with alternating dark brown and pale bluish bands; caudal spine bright orange; dorsal and anal fins black with a narrow blue line at the base which becomes broader posteriorly; anal fin with a narrow blue margin; caudal fin dark brown, shading to black peripherally except narrow margin which is blue; pectoral fin light brown on upper half, dusky blue on lower half, with a black margin all around fin; pelvic fins black with narrow blue margin.

Although this species reaches a large size (at least 270 mm. in standard length), it has a small acronurus. The transforming specimen shown in Figure 1*g* is 21 mm. in standard length.

Acanthurus sohal appears to be confined to the Red Sea.

Al=Hussaini (1947: 40, fig. 10) described the anatomy of the alimentary tract of this species. He stated that it feeds on various kinds of algae, but ingests large amounts of *Sargassum*. I examined the gut content of a 122 mm. specimen; it consisted primarily of fine filamentous green algae.

Fowler and Bean (1929: 216) erroneously applied the name *sohal* to the species *Acanthurus tennenti* Günther.

Acanthurus leucocheilus Herre
Fig. 14

Acanthurus leucocheilus Herre (1927: 419, pl. 12, fig. 3) (Philippine Islands); de Beaufort (1951: 140).

The following is based on Herre's description of three specimens, 175 to 200 mm. long, from Bantayan Island, and a 196 mm. spec-

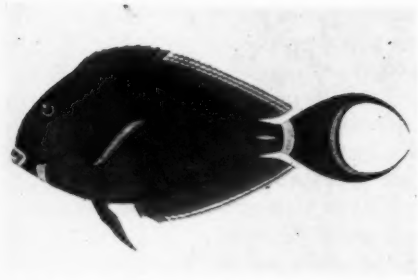


FIG. 14. *Acanthurus leucocheilus* (after Herre, 1927).

imen from Cebu: dorsal rays IX, 24 or 25; anal rays III, 23; 9 or 10 teeth with broad lobate tips on each side of upper jaw and 10 or 11 on each side of lower jaw; depth of body 2 to 2.4 in length; head 3.3 to 3.7 in length; snout 1.3 to 1.44 in head; eye 3.6 to 3.9 in head; eye 1.07 to 1.28 in interorbital; caudal deeply lunate with long pointed tips (caudal concavity in figure about 3.5 in standard length); length of pectoral approximately equal to length of head; first ventral ray elongate, 1.1 to 1.25 in head. Color (in alcohol) blackish brown; snout just above and behind lips black; a bluish white band encircling mouth (though it may be only partially developed on upper lip); a similar but wider white band across chest; a broad bluish white band around base of caudal; pectoral black with a white bar on posterior third; dorsal, anal, and pelvic fins black or brownish black; caudal fin black, sometimes with a bluish white lunate band near posterior margin; caudal spine white, its groove with a narrow black margin. A fresh specimen, 186 mm. in length, from Agutaya, one of the Cuyo Islands, was blackish brown above, deep brown elsewhere except cheeks and snout which were reddish brown; lips reddish with a bluish band around mouth; the chest band was bluish white; soft dorsal fin with three and anal fin with two dark red lines near margin alternating with bluish; narrow margin of these fins sky blue, posteriorly brick red; caudal fin very dark brown with a wide bluish white band around base and a submarginal blue band posteriorly; pectoral blackish brown with a bright yellow bar on posterior third, the margin with rays dusky, membranes clear; pelvics black basally and along outer margin, the rest brick red.

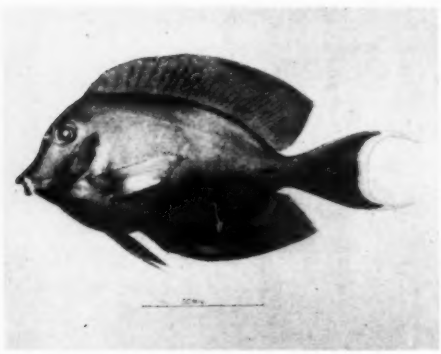


FIG. 15. *Acanthurus pyroferus*. 113 mm. specimen, Marshall Islands (after Schultz and Woods, 1953, retouched).

The types of this species were destroyed in Manila during World War II, and to my knowledge, no other specimens are in existence. Herre (1934: 62) recorded the species (as *Acanthurus leucocheilos*) from a specimen (Stanford Mus. No. 26401) from the Philippines. I examined it and found that it is *Acanthurus pyroferus*.

Fowler and Bean (1929: 225) erroneously placed *Acanthurus leucocheilus* Herre in the synonymy of *Hepatus grammoptilus* (Richardson). The specimens which these authors identified as *grammoptilus* are *A. xanthopterus* and *A. dussumieri*. *A. leucocheilus*, as originally described, is probably a valid species.

Acanthurus pyroferus Kittlitz
Figs. 2*k*, 15

Acanthurus pyroferus Kittlitz (1834: 191, pl. 12, fig. 2) (Ulea Island = Woleai Atoll, Caroline Islands); Günther (1861: 337); Günther (1873: 113).

Acanthurus armiger Cuvier and Valenciennes (1834: 234).

Acanthurus celebicus Bleeker (1852: 761) (Macassar, Celebes); Kner (1865–67: 211) (Madras); Günther (1861: 339); Günther (1873: 115, pl. 73, fig. B) (Solomon Islands and Tahiti); Day (1889: 142) (Malay Archipelago); Herre (1927: 417, pl. 13, fig. 1) (Mindoro, Philippine Islands); de Beaufort (1951: 141) (Java and Adonare).

Acanthurus fuscus Steindachner (1861: 176, pl. 5) (Ambon, East Indies); Günther (1861: 339); de Beaufort (1851: 137).

Rhombotides celebicus Bleeker (1863*b*: 235) (Ternate, East Indies).

Acanthurus Celebicus Day (1876: 206) (Malay Archipelago).

Acanthurus tristis Tickell *in* Day (1888: 788) (Arraken, Burma); Myers (1951: 26).

Hepatus pyriferus Jordan and Seale (1906: 350) (error for *pyroferus*).

Hepatus celebicus Jordan and Seale (1906: 352); Jordan and Seale (1907: 34) (Philippine Islands).

Hepatus pyroferus Fowler (1928: 272).

Hepatus leucosternon. Fowler (1928: 272); Fowler and Bean (in part) (1929: 243, fig. 14) (Riu Kiu Islands, Philippine Islands, and East Indies); Aoyagi (1943: 207, text fig. 52, pl. 5, fig. 13) (Riu Kiu Islands).

Acanthurus leucocheilos. Herre (1934: 62) (Linapacan, Philippine Islands).

Acanthurus leucosternon. Schultz and Woods *in* Schultz *et al.* (1953: 626, pl. 61, fig. B) (Bikini Atoll, Marshall Islands).

Dorsal rays VIII, 27 or 28; anal rays III, 24 to 26; pectoral rays 16; anterior gill rakers 23 to 26; posterior gill rakers 25 to 27 (raker counts from four specimens from the Marshall Islands); a 109 mm. specimen has 14 upper and 16 lower teeth; a 145 mm. specimen has 16 upper and 18 lower teeth; a 159 mm. specimen has 16 upper and 21 lower teeth.

Snout somewhat produced; snout length 4.6 to 4.7 in standard length; caudal fin lunate, caudal concavity 4 to 5 in standard length; longest dorsal ray about 4.5 in standard length.

TABLE 11
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus pyroferus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS		ANAL SOFT RAYS		
	27	28	24	25	26
Philippine Islands	5		1	4	
Marshall Islands	2	2		2	2

Color from a 35 mm. Kodachrome transparency (given to me by Leonard P. Schultz) of a Marshall Islands specimen (reproduced in black and white herein as Figure 15): purplish black with an orange area, higher than wide, at edge of gill opening just above base of pectoral fin; a diffuse patch of orange anterior to base of pectoral and a trace of orange just behind eye; a broad black band beginning at upper end of gill opening and extending on to margin of gill cover down to isthmus (this band is more apparent in preserved specimens, as is a black band at the base of the dorsal fin, one at the base of the anal fin, blackish lips, and a narrow black margin around caudal spine socket); a white line under chin extending slightly above rictus; median fins black except for a broad posterior band on back edge of caudal fin which is pale yellow; pectoral fin blackish, especially basally on rays, with a large pale yellow spot in lower central part of fin.

Kittlitz (1834) stated that the species is common at Ulea (Caroline Islands), and the young are dirty yellow in color. I have seen no juvenile specimens of this species. It is possible that Kittlitz might have confused the young of *Acanthurus olivaceus*, which are yellow, with *Acanthurus pyroferus*.

Acanthurus pyroferus occurs in the East Indies and Philippines and into the Indian Ocean at least as far as India. It ranges out into the tropical central Pacific; however it is recorded from only a few of the major island groups. De Beaufort (1951: 142) lists the species (as *A. celebicus*) from Hawaii. In this I believe he is in error.

I know of no type specimen of *Acanthurus pyroferus* Kittlitz. Although no one has identified a specimen of *Acanthurus* as *pyroferus* since Kittlitz (1834), and de Beaufort (1951: 138) regarded it as a problematic species, there is little doubt that it is the same as *Acanthurus celebicus* Bleeker. Kittlitz' figure shows the vertically aligned orange area, which is edged in black, just above the pectoral fin and the prominent, uniformly broad, yellow, posterior margin on the caudal fin. The dorsal and anal fins are relatively elevated, and the snout is produced (although this feature seems to be exaggerated). The dorsal and anal fin ray counts (D VII, 29; A III, 25) check closely (as in most species of *Acanthurus*, the first dorsal spine is very short and covered with skin; it could have been overlooked by Kittlitz, or he may have counted the eighth spine as a soft ray). The narrow ring of white under the chin is not present on the figure, nor is it mentioned in the description. Probably it was missed. There are greater omissions than this from some of the figures and descriptions of better known species of acanthurids from the same paper.

Herre (1927: 418) observed two living specimens from the Philippines and reported that the amount and intensity of red color behind the head and about the pectoral base vary considerably according to light conditions and the state of excitement of the fish.

Acanthurus tristis Tickell (Day) was described as having a caudal fin "nearly white externally" and an irregular black band from the upper edge of the orbit across the top of the opercle to the base of the pectoral fin. Although I have not seen a specimen of *Acanthurus pyroferus* with the black band extending to the eye, Herre's plate (1927: pl. 13, fig. 1) shows this pattern, and I consider it as probably within the range of variability of the species.

Acanthurus pyroferus appears to link the group of three species, *Acanthurus leucosternon*, *Acanthurus glaucopareius*, and *Acanthurus achilles* with the last 11 Indo-West-Pacific species as discussed in this paper (species such as *A. olivaceus*, which have a distinctive color mark on the shoulder region, and large species such as *A. xanthopterus*) and the Atlantic species except *A. coeruleus*. *A. pyroferus* is intermediate in dorsal and anal fin ray counts, tooth structure, and tooth counts. It has a produced snout and white line on the chin in common with the former group and the large, round, gizzard-like stomach of the latter.

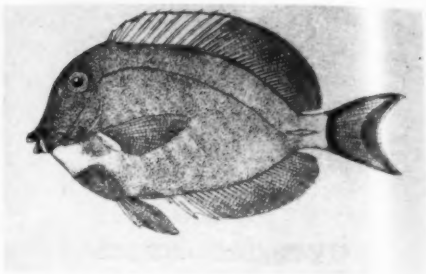


FIG. 16. *Acanthurus leucosternon* (after de Beaufort, 1951).

Acanthurus leucosternon Bennett
Figs. 2*l*, 16

Acanthurus leucosternon Bennett, E. T. (1832: 183) (Ceylon); Bleeker (1853*b*: 48); Bleeker (1856–57: 237) (Batoe Islands, Sumatra); Günther (1861: 340) (Ceylon); Playfair *in* Playfair and Günther (1866: 56) (Zanzibar); Day (1876: 203); de Beaufort (1951: 139, fig. 26) (Pulu Weh and coast of Deli, Sumatra).

Acanthurus Delisiani Cuvier and Valenciennes (1835: 193) (Mauritius).

Acanthurus Delisianus Valenciennes *in* Cuvier (1837: pl. 45); Guérin (1844: pl. 35, fig. 2).

Rhombotides leucosternon Bleeker *in* Bleeker and Pollen (1874: 97).

Acanthurus leucosternum Day (1889: 138).

Dorsal rays IX, 30; anal rays III, 27; pectoral rays 16; 11 upper teeth and 12 lower teeth. All counts based on one 173 mm.

specimen from Mauritius in the Museum of Comparative Zoology at Harvard College. This specimen, the only one which I have examined, was used for the proportional measurements and color description below.

Body depth 1.7 in standard length; caudal concavity 13 in standard length; longest dorsal ray 5.4 in standard length; caudal spine 3 in head length.

Color in alcohol: body bluish gray; head dark brown; chin with a chalky white line at edge of lip which extends a distance equivalent to half the diameter of an eye above the rictus and narrows to a point apically; a broad chalky white band on chest, as wide as depth of caudal peduncle, extending to base of pectoral fin; caudal fin with a white posterior marginal band (equal in width to one-third the diameter of the pupil of the eye), a brownish black submarginal band (an eye diameter in width centrally, but narrowing toward lobes where it meets brownish black upper and lower edges of caudal fin), and a narrow brownish black band across base which connects the dark upper and lower margins of caudal lobes; dorsal fin pale yellow with a narrow white marginal line on upper edge and a black submarginal line; anal fin pale yellow with narrow white outer margin and white line at base; pectoral fin pale yellow; pelvic fins purplish gray with a white margin; region around caudal spine slightly paler than body.

Acanthurus leucosternon resembles *Acanthurus achilles* and *Acanthurus glaucopareius* in morphology and color. It ranges from East Africa to the East Indies, and does not appear to be a common species.

Fowler (1928), Fowler and Bean (1929), Aoyagi (1943), and Schultz and Woods (1953) were all in error in their use of the name *leucosternon* for the species *Acanthurus pyroferus*.

Acanthurus glaucopareius Cuvier
Figs. 1*l*, 2*m*, Pl. 2

Acanthurus glauco-pareius Cuvier (1829: 224) (after Seba) (Günther, 1861, gives the type locality as Tahiti).

Acanthurus ali-ala Lesson (1830: 150) (Oualan).

Acanthurus glaucopareius Kittlitz (1834: 192, pl. 13, fig. 3) (Ulea Island = Woleai Atoll, Caroline Islands); Cuvier and Valenciennes (1835: 190) (Tahiti); Bleeker (1856: 47) (Ambon, East Indies); Günther (1861: 339) (Ambon, East Indies and Tahiti); Günther (1873: 114, pl. 71, fig. A) (Polynesia and East Indies); Schultz (1943: 161) (Phoenix and Samoa Islands); Marshall, N. B. (1950: 194) (Cocos-Keeling Islands); Palmer (1950: 202) (Christmas Island, Indian Ocean); de Beaufort (1951: 138) (Ambon, Misol, and New Guinea).

Rhombotides glaucopareius Bleeker (1865: 288) (Ambon, East Indies).

Teuthis aliala Jordan and Evermann (1898: 1693) (Clarion and Socorro Islands, western Mexico); Jordan and McGregor (1899: 280) (Clarion and Socorro Islands); Seale (1901: 109) (Guam).

Hepatus aliala Snodgrass and Heller (1905: 403) (Cocos Island and Clipperton Island); Jordan and Seale (1906: 350) (Samoa); Aoyagi (1943: 209, pl. 8, fig. 2, pl. 6, fig. 19) (Okinawa).

Acanthurus aliala Herre (1927: 416, pl. 2, fig. 2) (Philippine Islands); Herre (1936: 241) (Cocos Island off Costa Rica, Marquesas Islands, Tuamotu Archipelago, and Society Islands); Schultz and Woods *in* Schultz *et al.* (1953: 627, pl. 65, fig. A) (Marshall Islands).

Hepatus glaucopareius Fowler (1928: 272) (Oceania); Fowler and Bean (1929: 246) (Philippine Islands, Guam, Samoa, and Honolulu).

Hepatus aliala japonicus Schmidt (1930*b*: 102, pl. 6, fig. 3) (Riu Kiu Islands).

Teuthis glaucopareius Whitley and Colefax (1938: 297) (Nauru Island).

Hepatus glauco-pareius Fowler (1938: 103) (Takaroa, Tuamotu Archipelago).

Teuthis japonicus Fowler (1946: 197).

Teuthis glauco-pareius Fowler (1949: 103) (Jarvis Island).

Acanthurus sp. one Harry (1953: 149) (Raroia, Tuamotu Archipelago).

Dorsal rays IX, 28 to 31; anal rays III, 26 to 28; pectoral rays 16; anterior gill rakers 17 to 19; posterior gill rakers 18 to 20 (raker counts from specimens from the Phoenix Islands); 80 mm., 108 mm., and 133 mm. specimens have 10 upper and 10 lower teeth; 153 mm. and 171 mm. specimens have 10 upper and 12 lower teeth.

TABLE 12
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus glaucopareius* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS		
	28	29	30	31	26	27	28
East Indies			1			1	
Philippine Islands	1				1		
Mariana Islands		1	1		1	1	
Marshall Islands	2	6	6	1	2	12	1
Gilbert Islands	1	7	3	1	5	6	1
Samoa Islands		3	4	1	2	5	1
Phoenix Islands	1	3	6	2	3	9	
Tuamotu Archipelago	2	3	4		2	5	2
Marquesas Islands		1			1		
Line Islands		1				1	
Galapagos Islands		1	1	1		2	1
Cocos Island, Costa Rica	1	3	4		2	4	2
Hawaiian Islands		1	1			2	

Depth of body 1.7 to 1.85 in standard length; caudal concavity 10 to 14.5 in standard length; width of mouth from rictus to rictus 4.5 to 5.3 in head length; length of snout 4 to 4.3 in standard length.

Color (in alcohol) dark purplish brown; a whitish elliptical area below and adjacent to eye; a pale line under chin extending and narrowing about one-half eye diameter in distance above rictus; no pale area around caudal spine and no white mark on opercle; caudal fin abruptly yellowish white with a pale yellow band (the posterior edge of which is bordered with a narrow dark line), about one-fourth to one-third the diameter of the eye in width, in outer part of fin paralleling posterior margin; dorsal and anal fins colored like body except basally where there is a prominent pale yellowish white (yellow in life) band which broadens posteriorly in fin to about three-fourths the length of the last few rays; dorsal and anal fins with a narrow white margin and a black submarginal line; rays of pectoral fin dusky, membranes clear; pelvic fins dark with narrow pale outer margin.

Marshall (1950: 194) and Palmer (1950: 202) recorded a color form of this species which co-exists with the normal one at Cocos-Keeling Islands and Christmas Island, respectively, in the Indian Ocean. The salient feature of this form is the lack of the usual sharp dividing line in color at the caudal flexure. There is a gradual blending of dark body color and pale caudal color over the proximal one-third of the fin. Also the dorsal and anal fins are paler.

Schmidt (1930*b*: 102, pl. 6, fig. 3) described a subspecies, *Acanthurus glaucopareius japonicus*, from the Riu Kiu Islands which Fowler (1946: 197) elevated to species rank. Aoyagi (1943: 210), however, observed this form occurring with the typical *Acanthurus glaucopareius* in the Riu Kius and found intermediates between the two. I examined a 90 mm. specimen of the *japonicus* form at the Academy of Natural Sciences of Philadelphia. It differs from the normal *glaucopareius* chiefly in the presence of a broad pale band running from the eye to the posterior half of the upper lip and a large pale spot at the base of the pectoral fin. There are no obvious meristic differences; the counts of this specimen are: D IX, 28; A III, 26; P 16; 10 upper teeth; 10 lower teeth.

Schultz (1943: 157, 163, fig. 13) described *Acanthurus rackliffei* from the Phoenix Islands. He noted the similarity to *Acanthurus glaucopareius* and *Acanthurus achilles*. In my opinion *A. rackliffei* is a hybrid between these two species (Randall, in press, *d*).

Acanthurus glaucopareius, *Acanthurus achilles*, and *Acanthurus leucosternon* stand apart from other species of the genus principally in having a produced snout, a small mouth with few, relatively large teeth of distinctive structure, a high body, dark purplish color, and a white line on the chin. Also, at least in *A. achilles* and *A. glaucopareius*, the size at transformation from the acronurus to the juvenile stage is very large, about 55 to 60 mm. in standard length. These differences would probably warrant recognition of this group as a subgenus were it not for *Acanthurus pyroferus* which links these three to other species of *Acanthurus*.

The largest specimen of *A. glaucopareius* examined by me measures 171 mm. in standard length. It was collected from Enderbury Atoll in the Phoenix Islands.

Acanthurus glaucopareius appears to be absent from the Indian Ocean except for Christmas and Cocos-Keeling Islands. It occurs in the East Indies and Philippine Islands and is recorded from most of the island groups of the tropical Pacific. It is one of the three species of *Acanthurus* to have crossed the eastern Pacific barrier; it seems to be common in the waters of the Galapagos Islands, Cocos Island, and the Revillagigedo Islands (Mexico). It is usually abundant where it is found; however it is probably the rarest of the species of surgeon fishes in the Hawaiian Islands.

In atolls of the Gilbert Islands, *A. glaucopareius* was most commonly seen on the coralliferous terrace of the outer reef, especially near the entrances to surge channels; however, it was often observed in coral-rich areas of more sheltered waters.

Many authors have used the name *Acanthurus aliala* Lesson (1830) for this species. It is true that the name *glaucopareius* does not appear on page 212 of Bloch and Schneider (1801) even though a description which fits this species can be found on this page in a separate section under the heading *Acanthurus nigricans*. Cuvier's listing (1829: 224) of *Acanthurus glaucopareius* and reference to the work of the prelinnaean author Seba (1758) who figured the species, however, clearly predates Lesson.

Acanthurus achilles Shaw
Figs. 1*k*, 2*n*, Pl. 2

Acanthurus Achilles Shaw (1803: 383) (no locality); Cuvier and Valenciennes (1835: 218).

Acanthurus achilles Günther (1861: 340) (China); Günther (1873: 115, pl. 71, fig. B) (Polynesia); Waite (1897: 188) (Funafuti, Ellice Islands); Steindachner (1901: 493) (Honolulu); Jordan and Jordan (1922: 65) (Hawaiian Islands); Herre (1927: 414, pl. 2, fig. 1) (Guam); Schultz (1943: 162) (Phoenix and Samoa Islands); Schultz and Woods *in* Schultz *et al.* (1953: 629, pl. 65, fig. B) (Marshall Islands); Harry (1953: 147) (Raroia, Tuamotu Archipelago).

Acanthurus aterrimus Günther (1873: 114, pl. 77, fig. B) (Samoa).

? *Acronurus formosus* Castelnau (1873: 104) (Torres Strait); Macleay (1881: 528).

Teuthis achilles Fowler (1899: 494) (Caroline Islands); Jenkins (1903: 475) (Hawaiian Islands).

Hepatus achilles Jordan and Evermann (1905: 384, pl. 58) (Honolulu); Jordan and Seale (1906: 350) (Samoa); Fowler (1928: 273) (Oceania); Fowler and Bean (1929: 247) (Fanning Island, Samoa, and Hawaiian Islands); Fowler (1938: 104, 184) (Takaroa, Tuamotu Archipelago and Tongareva).

Hepatus aterrimus Jordan and Seale (1906: 351); Fowler (1928: 268) (Society Islands); Fowler and Bean (1929: 243).

Teuthis aterrimus Fowler (1949: 103).

Dorsal rays IX, 29 to 33; anal rays III, 26 to 29; pectoral rays 16; anterior gill rakers 16 to 20; posterior gill rakers 18 to 20 (raker counts from specimens from the Phoenix Islands); 84 mm., 140 mm., and 155 mm. specimens have 8 upper and 10 lower teeth; a 185 mm. specimen has 10 upper and 12 lower teeth.

TABLE 13
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus achilles* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS					ANAL SOFT RAYS			
	29	30	31	32	33	26	27	28	29
Marshall Islands	2	10	12	7		1	7	14	9
Gilbert Islands			4				1	3	
Samoa Islands		6	10	16			4	13	15
Phoenix Islands	1	3	5	2			3	6	2
Line Islands	2	1	2			1	1	2	1
Malden Island	1	1	1				3		
Wake Island		3	3	1			2	4	1
Hawaiian Islands	1	4	8	4	2	1	4	8	6
Johnston Island			8	2				6	4

Depth of body 1.75 to 1.9 in standard length; caudal concavity 5.5 to 8 in standard length; width of mouth from rictus to rictus 4.5 to 6 in head length; length of snout 3.9 to 4 in standard length.

Color (in alcohol) blackish brown with a large oval pale yellow (orange in life) area extending forward from rear of caudal spine; broad median portion of opercular membrane snow white; pale line on chin ending at rictus; basal one-third of caudal fin dark like body; next one-third of fin light orangish brown, bordered posteriorly with a prominent black band which follows the contour of the hind edge of the fin; outer one-fourth to one-third of caudal fin white; dorsal and anal fins colored like body except for a pale line at the base which is only slightly broader posteriorly than anteriorly and a narrow white margin; pectoral rays black, membranes pale; pelvics dark brown with outer margins white.

The large elliptical orange spot on the posterior part of the body of *A. achilles* does not appear until a standard length of about 65 to 70 mm. is attained. Günther (1873) described a juvenile *A. achilles* which had not yet developed its orange spot as a new species, *A. aterrimus*. Schultz (1943: 162) corrected this error.

The acronurus of *A. achilles* (Fig. 1*k*) reaches a large size, about 60 mm. in standard length. It is spotted with black, a characteristic which one usually associates with the acronuri of *Naso*.

Acronurus formosus Castelnau may be the acronurus of *A. achilles*. It was described as having four rows of black spots and the dorsal and anal fin ray counts were high as in *achilles*. Whitley (1940: 425) selected the largest of Castelnau's specimens (62 mm. in standard length) as lectotype and figured it (fig. 42), but did not show any spots. Whitley's counts are also high (D VIII, 31?; A III, 32?). The specimen was collected from the Torres Strait which separates New Guinea from Australia. *Acanthurus achilles* is not recorded from the East Indies, which suggests that the specimen may be the acronurus of *A. leucosternon* which I have not seen.

Acanthurus achilles is common throughout Oceania. It is not known from the Indian Ocean. With the possible exception of the specimen of *Acronurus formosus*, it appears to be absent from the East Indies. The only record of *A. achilles* from the Philippine Islands is the listing of the name with a question mark by Elera (1895: 532). As he did not include *A. glaucopareius* among the surgeon fishes in his catalog, it seems possible that he might have confused these two species. Herre (1927) included *A. achilles* in his work on Philippine surgeon fishes only because he believed the species should occur there. Fowler and Bean (1929) did not find any specimens among the extensive "Albatross" collections of fishes from the Philippines and East Indies; these authors recorded the species from the Philippines on the strength of Elera's dubious record. Herre (1953: 532) erred in listing *achilles* in his checklist of fishes of the Philippines on the basis of his 1927 work. *A. achilles* is not known from the Riu Kiu Islands or Japan. Günther (1861: 340), however, listed it from China; this record is inconsistent with the known distribution and should be checked.

Acanthurus achilles is most often found in inshore regions of moderately rough water.

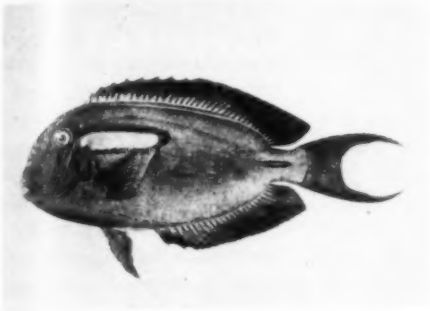


FIG. 17. *Acanthurus olivaceus* (after Schultz and Woods, 1953, retouched).

At atolls in the Gilbert Islands the species was frequently observed in surge channels of the windward reef.

The largest specimen seen by me is 195 mm. in standard length; it was collected at Malden Island.

For further remarks on *A. achilles* see discussion under *A. glaucopareius*.

Acanthurus olivaceus Bloch and Schneider
Figs. 1*f*, 2*o*, 17

Acanthurus Nigricans var. *Olivaceus* Bloch and Schneider (1801: xxxviii, 213–214) (Tahiti).

Acanthurus eparei Lesson (1830: 147, pl. 27, fig. 1) (Tahiti).

Acanthurus olivaceus Kittlitz (1834: 189, pl. 12, fig. 1) (Caroline Islands); Günther (1861: 336) (Tahiti and Fiji Islands); Günther (1873: 113) (East Indies and South Seas); Steindachner (1901: 493) (Honolulu); Jordan and Jordan (1922: 65) (Hawaiian Islands); Herre (1927: 413, pl. 12, fig. 1) (Philippine Islands); Schultz (1943: 166) (Samoa Islands); de Beaufort (1951: 154) (East Indies); Schultz and Woods *in* Schultz *et al.* (1953: 632, pl. 67) (Marshall Islands).

Acanthurus humeralis Cuvier and Valenciennes (1835: 231) (Caroline Islands and Tahiti); Eydoux and Souleyet (1841: 169, pl. 2, fig. 3) (Hawaiian Islands); Bleeker (1852: 762) (Macassar, Celebes).

Ctenodon erythromelas Swainson (1839: 256) (error or emendation for *Acanthurus eparei* Lesson).

Harpurus paroticus Forster (1844: 183).

Acanthurus chrysosoma Bleeker (1857: 67) (Kajeli); Günther (1861: 332); de Beaufort (1951: 165) (East Indies).

? *Rhombotides xanthosoma* Bleeker (1865: 288) (error for *chrysosoma*?).

Rhombotides olivaceus Bleeker (1865: 288) (Ambon, East Indies).

Teuthis olivaceus Seale (1901: 107) (Guam); Jordan and Evermann (1902: 358, fig. 23) (Formosa); Jenkins (1903: 476) (Hawaiian Islands).

Hepatus olivaceus Jordan and Evermann (1905: 385, fig. 166); Jordan and Seale (1906: 350) (Samoa); Jordan and Richardson (1908: 270) (Cagayancillo, Philippine Islands); McCulloch (1922: 243) (Capricorn Islands, Queensland); Fowler (1928: 271) (Oceania); Fowler and Bean (1929: 231) (Philippine Islands, Okinawa, Samoa, and Hawaiian Islands); Schmidt (1930*a*: 556) (Riu Kiu Islands); Fowler (1931: 345) (Honolulu); Fowler (1938: 232) (Honolulu); Aoyagi (1943: 211, pl. 5, fig. 15, teeth only) (Riu Kiu Islands); Hiyama (1943: 94, pl. 20, fig. 55).

Hepatus chrysosoma Fowler (1928: 269); Fowler and Bean (1929: 214).

Dorsal rays IX, 23 to 25; anal rays III, 22 to 24; pectoral rays 16 or 17 (usually 17); anterior gill rakers 24 to 28; posterior gill rakers 23 to 27 (raker counts from Hawaiian specimens); a 44 mm. specimen has 14 upper and 14 lower teeth; a 123 mm. specimen has 14 upper and 16 lower teeth; a 138 mm. specimen has 16 upper and 18 lower teeth; a 208 mm. specimen has 18 upper and 20 lower teeth; a 225 mm. specimen has 20 upper and 21 lower teeth.

Caudal fin of adults strongly lunate, caudal concavity (in specimens greater than 180 mm. in standard length) contained 4 to 5 times in standard length; in specimens about 100 mm.

TABLE 14
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus olivaceus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	23	24	25	22	23	24
Philippine Islands		3		1	2	
Okinawa	1	2		1	2	
Mariana Islands		2		1		1
Caroline Islands	1			1		
Marshall Islands	2	12	4	3	9	6
Gilbert Islands		1	1	1		1
Samoa Islands	2	3		2	3	
Society Islands	1	1			2	
Hawaiian Islands	2	13	3	5	10	3
Johnston Island			1		1	

in standard length, the caudal concavity is contained about 9 times in the standard length; snout length 4.5 to 4.9 in standard length; longest soft dorsal ray 5.5 to 6 in standard length; eye of 104 mm. specimen 3.3 in head length; eye of 208 mm. specimen 4.5 in head length; caudal spine of 104 mm. specimen 3.5 in head length; caudal spine of 208 mm. specimen 2.5 in head length.

Large adult males (about 170 mm. or greater in standard length) develop a definite convexity in the profile of the snout which may permit determination of the sex of specimens without resorting to examination of the gonads. This sexual dimorphism of large adults is evident to a greater or less degree in the remaining Indo-West-Pacific species considered in this work and possibly also the Atlantic species except *A. coeruleus*. In most of the species the profile of the head of the female also becomes more convex with age. Males the same size, however, show distinctly greater convexity than females. All of these species have a large, round, very thick-walled stomach.

'Color in life from a 35 mm. Kodachrome transparency taken by the author of a 132 mm. specimen speared at Arno Atoll, Marshall Islands: dark grayish brown with a bright orange horizontal band, broadly bordered with purplish black, extending posteriorly from upper end of gill opening a distance greater than the length of the head; a dull orange line at base of dorsal fin; a similar, but fainter, line at base of anal fin; a large crescentic white area in centro-posterior part of caudal fin; rest of caudal fin, especially the lobes, spotted with dark brown; other fins colored like body except outer portion of pectoral which is pale; a faint longitudinal banding may be seen in soft portion of dorsal fin. Many adult specimens have been observed on which the color of the body posterior to a vertical at about the level of the fifth dorsal soft ray is much darker than that in front of this demarcation.

D. W. Strasburg (MS) has pointed out that the young of *Acanthurus olivaceus* are yellow. From a transformation size of about 29 mm. in standard length to a length of about 55 mm. the body color is bright yellow. The margins (except posterior) of the median fins and lateral outer edge of the pelvic fins are narrowly black. At a size of about 45 mm. in standard length the mark on the shoulder region first makes its appearance as a small dusky area. Specimens larger than about 55 mm. in standard length show a progressive accumulation of brown pigment until, at a standard length of about 85 mm., the brown color predominates. The shoulder bar first acquires a pale orange center at a standard length of about 55 mm.

Acanthurus chrysosoma Bleeker is probably the young of *Acanthurus olivaceus*. Bleeker's type specimens were 43 to 51 mm. in length. The color when fresh was orange-yellow with brownish edges on the dorsal, anal, and caudal fins.

A. olivaceus occurs from the East Indies to Oceania. Records from the Indian Ocean, such as from Mauritius, all appear to be the closely related *A. tennenti*.

A. olivaceus is usually found in fairly deep water, about 30 feet or more in depth. It is most commonly seen where much of the bottom is sandy.

Acanthurus tennenti Günther
Figs. 2*p*, 18

Acanthurus tennenti Günther (1861: 337) (Ceylon); Day (1889: 140).
Acanthurus Tennentii Day (1876: 204).
Acanthurus plagiatus Peters (1876: 439) (Mauritius).
Acanthurus olivaceus. Sauvage (1891: 343) (Mauritius).
Hepatus sohal. Fowler and Bean (1929: 216) (locality unknown).

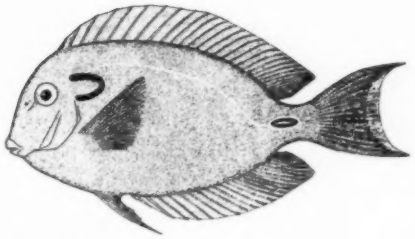


FIG. 18. *Acanthurus tennenti*. 116 mm. specimen, locality unknown. Drawing by author.

Dorsal rays IX, 23 or 24; anal rays III, 22 or 23; pectoral rays 16 (fin ray counts from 7 specimens from Mauritius and Ceylon); anterior gill rakers 25, posterior gill rakers 25 (based on one specimen); a 105 mm. specimen has 15 upper and 16 lower teeth; a 214 mm. specimen has 20 upper and 22 lower teeth.

Caudal fin lunate, caudal concavity varying from 10 in standard length of a 105 mm. specimen to 5 in standard length of a 214 mm. specimen.

Color (in alcohol) brown with a horseshoe-shaped black mark (open end pointing anteriorly) just behind upper edge of gill opening, at level of eye (in specimens of about 120 mm. or more in standard length this mark is broken posteriorly, forming two longitudinal curved bands; in very large specimens these bands are straighter, more elongate, and attenuate posteriorly); caudal spine enclosed in a prominent black area which, in turn, is surrounded by a bluish white region. This dark area becomes progressively larger with age and its bluish white margin relatively narrower (in a 214 mm. specimen the black area was oval in shape, slightly more pointed anteriorly, 37 mm. in length and 16 mm. high; the bluish white margin was a little greater than 1 mm. in width); caudal fin with a broad crescentic white area posteriorly; large specimens with pale margins on the very elongate upper and lower caudal lobes; dorsal and anal fins brown with no trace of banding; pectoral fin brown with a broad pale posterior margin (more distinct in large specimens); pelvic fins brown.

Fowler and Bean (1929: 216) misidentified a 116 mm. specimen of this species (U.S.N.M. No. 21294) as *Hepatus sohal*. It is this specimen which I have drawn as Figure 18. No field data or locality are available.

A. C. Wheeler kindly sent an X-ray, a drawing, and other data on the type specimen in the British Museum. The specimen is 103 mm. in standard length and is conspecific with the Fowler and Bean specimen.

Peters (1876: 439) described *Acanthurus plagiatus* as having two elongate triangular black marks on the shoulder, a black area with blue margin around the caudal spine, and a lunate caudal fin with a broad yellow posterior margin and a narrow yellow edge on the upper and lower caudal lobes. Had I not seen the five specimens in the Museum of Comparative Zoology at Harvard College which connect the large *plagiatus* form to *A. tennenti* of a little over 100 mm. in standard length, I would have probably considered Peters' species as valid.

Acanthurus tennenti is very closely related to *Acanthurus olivaceus*, and, with the possible exception of pectoral fin ray counts (more specimens needed), I can separate the two only by color. To my knowledge they are not known from the same area, *A. tennenti* occurring in the Indian Ocean and *A. olivaceus* in the East Indies and Oceania. Sauvage (1891: 343) (after Liénard) recorded *A. olivaceus* from Mauritius; however, he described it as having

two oblong black marks on the suprascapular region, thus indicating that he had a large specimen of *A. tennenti*. It is possible that the distinction between *A. olivaceus* and *A. tennenti* is subspecific; however, the color differences as noted in the key are greater than those seen on other similar pairs of acanthurids (such as *Acanthurus xanthopterus* and *Acanthurus mata*) which may be observed together.

Acanthurus fowleri de Beaufort
Fig. 2*q*, Pl. 3

Acanthurus bariene. Herre (in part) (*non* Lesson) (1927: 409) (Bantayan Island, Philippine Islands).

Hepatus pyroferus. Fowler and Bean (*non* Kittlitz) (1929: 232) (Philippine Islands and East Indies).

Acanthurus fowleri de Beaufort (1951: 149) (after Fowler and Bean).

Dorsal rays IX, 27; anal rays III, 25 or 26; pectoral rays 15 or 16; anterior gill rakers 23 to 25; posterior gill rakers 29 to 32. All counts based on five specimens from the Philippine Islands. A 165 mm. specimen has 17 upper and 18 lower teeth; a 270 mm. specimen has 18 upper and 20 lower teeth.

A 165 mm. specimen has a body depth which is contained 1.9 times in standard length, a snout length which is 4.4 in standard length, a caudal concavity which is 4.9 in standard length, an eye diameter which is 4.7 in head length, and a caudal spine length which is 3.7 in head length. A 270 mm. specimen has a body depth which is contained 2.3 times in standard length, a snout length which is 4.65 in standard length; a caudal concavity which is 4.4 in standard length, an eye diameter which is 5.7 in head length, and a caudal spine length which is 2.3 in head length.

Color (in alcohol) brown with numerous fine longitudinal pale lines on body which are about equal in width to the dark interspaces; a black triangular or horseshoe-shaped mark on shoulder region, the upper end of which is just above upper end of gill opening and the lower end approaches the upper part of the axil of the pectoral fin (the width of the band forming this mark is about one-half the diameter of the pupil of the eye); sheath of caudal spine and a broad margin around socket of spine black; base of caudal fin abruptly pale; upper and lower lobes of caudal slightly lighter than dark brown center of fin; pectoral fins brown with a large pale yellow spot in outer upper part; dorsal, anal, and pelvic fins brown.

Fowler and Bean (1929) were in error in calling this species *Hepatus pyroferus* (Kittlitz). De Beaufort (1951) realized this and proposed the name *Acanthurus fowleri*. Fowler and Bean give two detailed color descriptions for the species (1929: 233).

Herre (1927: 411) included in *Acanthurus bariene* a 240 mm. specimen from Bantayan Island which had a violet-black line encircling an area on the shoulder more than twice the size of the eye, the caudal fin with a bluish white ring at the base and the central part black, and the caudal spine in a black spot. Probably he was describing a specimen of *A. fowleri*.

Acanthurus fowleri is unknown outside the Philippine-East Indian region.

Acanthurus bariene Lesson
Fig. 2*r*, Pl. 3

acanthurus bariene Lesson (1830: 150) (Waigiou Island = Waigeo Island, New Guinea).

Acanthurus nummifer Cuvier and Valenciennes (1835: 234); Günther (1861: 338).

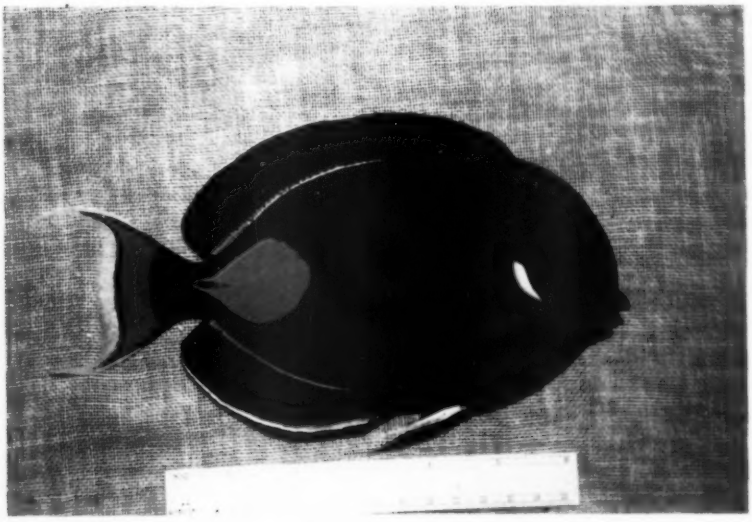
Acanthurus kingii Bennett, E. T. (1835: 119) (Port Praya).

Rhombotides nummifer Bleeker (1868: 297).

Hepatus bariene Jordan and Seale (1906: 352); Fowler and Bean (in part) (1929: 222) (Philippine Islands); Aoyagi (1943: 212, pl. 5, fig. 11, teeth only) (Okinawa).

Acanthurus bariene Herre (in part) (1927: 409,

Acanthurus glaucopareius, Gilbert Islands.



Acanthurus achilles, Hawaiian Islands.

pl. 1, fig. 2) (Philippine Islands); Smith (in part) (1949: 240) (Mozambique); de Beaufort (1951: 153).

Dorsal rays IX, 26 to 28; anal rays III, 25 or 26; pectoral rays 17 (fin ray counts based on six specimens from the Philippines); anterior gill rakers 19 to 23; posterior gill rakers 22 to 24 (raker counts from Philippine specimens); a 167 mm. specimen has 18 upper and 20 lower teeth; a 290 mm. specimen has 21 upper and 22 lower teeth.

Depth of body 1.9 to 2 in standard length; caudal concavity varying from 6.7 in standard length of 167 mm. specimen to 3.7 in standard length of 290 mm. specimen; longest dorsal ray varying from 4.9 in standard length of 167 mm. specimen to 5.3 in standard length of 290 mm. specimen.

Color (in alcohol) brown with numerous fine bluish gray longitudinal lines faintly visible on side of body; a round black spot, with a diameter about two-thirds that of eye, just above upper end of gill opening at level of eye (in some specimens this spot has a narrow pale blue margin); a dark brown area, about twice as high as maximum width of caudal spine, surrounding caudal spine; base of caudal fin abruptly pale, this pale region shading out a short distance on caudal lobes; central and posterior part of caudal fin brown; dorsal fin brownish yellow with narrow blue marginal and black submarginal lines, traces of dark longitudinal lines in outer part of fin, and a dark brown line at the base with a bluish gray line adjacent and distal to it; paired fins brown; opercular membrane dark brown.

H. W. Fowler and others have erred in applying the name *bariene* to the species *Acanthurus dussumieri* Cuvier and Valenciennes.

Acanthurus bariene appears to range from East Africa to the Riu Kiu Islands.

Acanthurus gahhm (Forskål)

Fig. 2*s*, Pl. 3

Chaetodon nigro-fuscus var. *Gahhm* Forskål (1775: xiii, 64) (Red Sea).

Chaetodon Gahm Linnaeus and Gmelin (1788: 1268).

Acanthurus gahm Cuvier and Valenciennes (1835: 219) (Red Sea and Mauritius); Günther (1861: 338); Klunzinger (1871: 506) (Red Sea); Günther (1873: 113, pl. 74) (Red Sea to the South Seas); Weber (1913: 318) (Saleyer, East Indies); Herre (1927: 411, pl. 12, fig. 2) (Philippine Islands); Herre (1936: 241) (Bora Bora and New Hebrides).

Acanthurus gahhm Bleeker (1858: 8) (Macassar, Celebes); de Beaufort (1951: 150) (East Indies).

? *Acanthurus gahmoides* Guichenot (1862: C. 8) (Réunion).

Rhombotides gahhm Bleeker (1865: 288) (Ambon, East Indies).

Acanthurus (*Rhombotides*) *gahm* Klunzinger (in part) (1884: 84) (Red Sea).

Hepatus nigricans. Jordan and Seale (1906: 351) (Samoa); Fowler (1923: 386) (Honolulu?); Fowler (1928: 272) (Oceania); Fowler and Bean (in part) (1929: 233) (Philippine Islands, East Indies, and Fiji).

Acanthurus gahm nigricauda Duncker and Mohr (1929: 75) (South Seas).

Acanthurus nigricans. Schultz (1943: 166) (Phoenix and Samoa Islands); Smith (1949: 240, pl. 36, no. 612) (east coast of Africa south to Durban); Schultz and Woods *in* Schultz *et al.* (1953: 633, pl. 68) (Marshall and Mariana Islands); Harry (1953: 148) (Raroia, Tuamotu Archipelago).

Hepatus nigrofuscus, Hiyama (1943: 94, pl. 20, fig. 56).

Dorsal rays IX, 25 to 28; anal rays III, 23 to 26; pectoral rays 17; anterior gill rakers 20 or 21; posterior gill rakers 20 to 26 (raker counts from Philippine specimens); a 25 mm. specimen has 14 upper and 14 lower teeth; a 46 mm. specimen has 15 upper and 16 lower teeth; a 74 mm. specimen has 16 upper and 16 lower teeth; a 135 mm. specimen has 16 upper and 18 lower teeth; a 170 mm. specimen

has 17 upper and 19 lower teeth; a 195 mm. specimen has 18 upper and 20 lower teeth; a 226 mm. specimen has 19 upper and 22 lower teeth. The number of denticulations on the teeth decrease with age (see Table 16).

TABLE 15
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus gahhm* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS			
	25	26	27	28	23	24	25	26
Mauritius		1		1		1	1	
New Guinea				1			1	
Philippine Islands	1	4	3		1	4	3	
Okinawa		1				1		
Palau Islands		3	4	1		1	4	3
Solomon Islands	1						1	
Fiji Islands	1				1			
Mariana Islands	1	1	2			1	2	1
Wake Island	2	2	1			3	1	1
Marshall Islands		3	4			4	3	
Gilbert Islands	1	7	4			4	7	1
Samoa Islands		1	2	1			4	
Phoenix Islands		1				1		
Society Islands			1				1	

Caudal fin progressively more lunate with age, caudal concavity 6.5 in standard length of 76 mm. specimen and 3.6 in standard length of 237 mm. specimen; depth of body varying from 1.9 in standard length of 76 mm. specimen to 2.2 in 237 mm. specimen; snout length 4.3 to 4.5 in standard length; caudal spine 7.5 in head length of 76 mm. specimen, 4.5 in head length of 237 mm. specimen.

Color (in alcohol) brown, without lines on the body or spots on the head; a horizontal black band (usually rounded posteriorly) running backward from upper edge of gill opening (this band first appears in specimens about 55 to 60 mm. in standard length; on a 96 mm. specimen the length of the band is contained 7.6 times in the standard length; on a 237 mm. one the band is 5.5 in the standard length); a long lanceolate black line extending anteriorly from caudal spine (this line does not appear until a standard length of about 100 mm. is attained; it becomes relatively longer in larger specimens and may reach half way from the caudal spine to the base of the pectoral fin on large specimens); caudal fin brown with prominent pale posterior margin (caudal fin of young entirely pale) which is broader in middle portion of fin, but narrows and disappears on caudal lobes (greatest width of posterior caudal margin of 96 mm. specimen contained 3.5 times in diameter of eye; greatest width of margin in 237 mm. specimen 4 in eye); base of caudal fin usually abruptly pale; outer one-third of pectoral fin pale (the inner half of this pale portion yellow in life); remaining fins brown.

Hiyama (1943: pl. 20, fig. 26) has figured the species [erroneously labelled *Hepatus nigrofuscus* (Forskål)] in the usual brown color form. Herre (1927: pl. 12, fig. 2) and Smith (1949: pl. 36, no. 612) have portrayed a bluish form with yellow dorsal and anal fins. Herre noted and figured an elongate dark blue spot on the nape anterior to the origin of the dorsal fin. He observed a living specimen in an aquarium which varied in color at different times from grayish blue to brownish gray. A specimen in the blue color phase with yellow fins was collected at Wake Island by W. A. Gosline and myself. It was not as light a blue as figured by Herre and by Smith but was

TABLE 16
THE CHANGE IN THE NUMBER OF DENTICULATIONS ON THE TEETH OF SPECIMENS OF *Acanthurus gahhm* OF INCREASING STANDARD LENGTH

STANDARD LENGTH (*mm.*)	NUMBER ON UPPER TEETH	NUMBER ON LOWER TEETH
25	17	17
35	15–16	11
42	15–16	11–12
48	14–15	10–11
57	14	10
75	12–13	9
115	10–11	8
135	9–10	8
168	9	7–8
191	7–8	7–8

dark purplish gray in color. An elongate purple mark was clearly visible just in front of the origin of the dorsal fin.

Forskål (1775: 64) listed *gahhm* as a variety of *Chaetodon nigrofuscus*. His description is incomplete, but it applies to the species as here interpreted better than any other known Red Sea species of the genus. The color of the fish was given as black with the base of the caudal fin violet and the hind margin of the pectoral fin yellow.

Many recent authors have used the specific name *nigricans* for *Acanthurus gahhm*. *Chaetodon nigricans* Linnaeus, however, appears to be a species of *Naso*. The species described by Hasselquist (1757: 332), to which Linnaeus refers in his listing of *Chaetodon nigricans*, is definitely a *Naso*.

Acanthurus gahhm ranges from East Africa to Oceania. It is known from most of the island groups in Oceania. There is only one record from the Hawaiian Islands, that of Fowler (1923: 386) who used the name *Hepatus nigricans* for the species. He included no descriptive information with the record, and I have been unable to locate his specimen(s). One adult specimen of *Acanthurus olivaceus* from Johnston Island in the Bishop Museum was identified as *Hepatus nigricans* by Fowler. It is possible that the single Hawaiian record is a misidentification.

At Onotoa Atoll in the Gilbert Islands, adult *Acanthurus gahhm* were commonly seen around isolated coral heads in sandy regions of the lagoon, and the young were abundant in lagoon tide pools. No juvenile or adult individuals were observed in outer reef areas.

Acanthurus maculiceps (Ahl)
Fig. 2*t*, Pl. 3

Hepatus maculiceps Ahl (1923: 36) (Talassia, New Britain); Fowler (1928: 269); Fowler and Bean (1929: 240, fig. 13) (Philippine Islands and East Indies); Aoyagi (1943: 212, text fig. 53, pl. 4, fig. 10) (Okinawa).

Hepatus nigricans. Fowler and Bean (in part) (1929: 233) (Celebes).

Acanthurus maculiceps de Beaufort (1951: 152).

Dorsal rays IX, 24 to 26, anal rays III, 23 or 24; pectoral rays 16; anterior gill rakers 19 to 23; posterior gill rakers 21 to 24 (raker counts from Philippine specimens); a 182 mm. specimen has 17 upper and 20 lower teeth; a 222 mm. specimen has 18 upper and 20 lower teeth.

TABLE 17
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus maculiceps* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	24	25	26	22	23	24
East Indies		2	1		2	1
Philippine Islands	1	6	3	2	5	3
Gilbert Islands	1	1			2	

Body depth 2 to 2.1 in standard length; caudal concavity varying from 5.7 in standard length of 182 mm. specimen to 3.5 in standard length of 228 mm. specimen; longest dorsal ray 5.4 to 5.5 in standard length; caudal spine 3.1 to 3.2 in head length.

Color (in alcohol) brown with numerous longitudinal paler brown lines on body (difficult to see on some specimens); a black bar, slightly greater than eye diameter in length, extending backward from upper edge of gill opening and often ending in a slight point; a second dark mark, less intense than the first and about the size of the pupil of the eye, just behind eye and often connected narrowly with the black bar; head with numerous pale spots (in average diameter slightly less than half the diameter of the pupil); all fins brown except for a vertical light gray band at base of caudal fin and pale yellow on outer third of upper six branched pectoral rays; nine dark brown longitudinal bands usually visible in dorsal fin; a very dark brown line, which is wider posteriorly, at base of dorsal fin; region around caudal spine dark brown.

The specimen shown in color in Plate 2 was collected from Binang Unang Island, Celebes, by the "Albatross" Expedition. It was misidentified as *Hepatus nigricans* by Fowler and Bean (1929: 236).

Acanthurus maculiceps is known at the present time only from the East Indies, Philippines, Riu Kiu Islands, and the Gilbert Islands.

A 193 mm. specimen collected by the author at Onotoa Atoll in the Gilbert Islands was speared at a depth of about 20 feet on the coralliferous terrace of the outer reef.

Acanthurus auranticavus Randall
Figs. 2*u*, 19

Hepatus nigrofuscus. Fowler and Bean (in part) (*non* Forskål) (1929: 237) (Philippine Islands and East Indies).

Holotype.—United States National Museum Number 136194, Atulayan Island, Lagonoy Gulf, east coast of Luzon, June 17, 1909, "Albatross" Expedition, 203 mm. in standard length.

Paratypes.—U.S.N.M. No. 163823, Mansalay, southeast Mindoro, June 4, 1908, "Albatross" Expedition, 144 mm. in standard length; U.S.N.M. No. 136202, Danawan Island, Borneo, September 27, 1909, "Albatross" Expedition, 208 mm. in standard length; U.S.N.M. No. 136188, Buang Bay, Talajit Island (between Samar and Masbate, Philippine Islands), March 15, 1909, standard length 217 mm. (to be sent to the British Museum); Stanford Mus. No. 47695, Atulayan Island, Lagonoy Gulf, Luzon, June 17, 1909, "Albatross" Expedition, two specimens, 179 and 207 mm. in standard length.

Description (data in parentheses are the extremes in counts and measurements for all the paratypes).—Dorsal rays IX, 26 (25 or 26); anal rays III, 24 (23 or 24, usually 24); pectoral rays 16 (16 or 17); anterior gill rakers 21 (20 to 23); posterior gill rakers 25 (24 to 28); scales from gill opening to posterior end of caudal spine 217 (195 to 233); number of upper teeth 18 (18 or 19); number of lower teeth 18 (18 to 20).

The following measurements are propor-

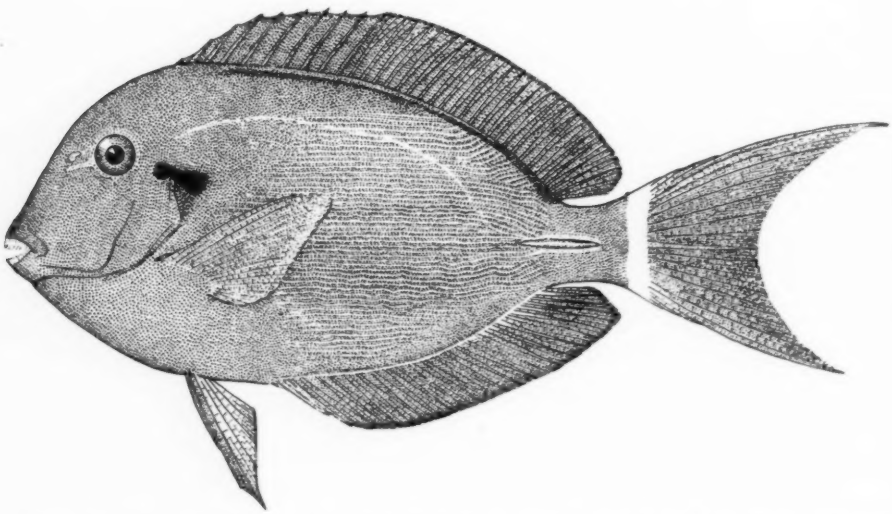


FIG. 19. *Acanthurus auranticavus*, n. sp. Drawing of holotype by Aime M. Awl, United States National Museum.

tions of the standard length: depth of body 2.09 (2.03 to 2.14); length of head 3.98 (3.57 to 3.89); length of snout 4.84 (4.58 to 4.94); length of pectoral fin 3.69 (3.35 to 3.78); length of pelvic fin 4.06 (4.12 to 4.60); pelvic spine 7.65 (6.55 to 8.62); ninth dorsal spine 6.67 (5.34 to 7.24); longest dorsal ray 5.80 (5.24 to 6.50); third anal spine 8.84 (7.39 to 9.44); longest anal ray 6.34 (5.24 to 6.26); caudal concavity 4.41 (4.21 to 6.75).

The following measurements are proportions of the head length: greatest diameter of eye 3.92 (3.51 to 4.53), width of interorbital space 2.76 (2.82 to 3.22), least depth of caudal peduncle 2.25 (2.33 to 2.76), length of caudal peduncle spine 2.22 (2.47 to 4.46), distance from base of upper lip to distal ends of upper teeth 5.67 (6.14 to 6.99).

Color in life of specimens including the holotype (identified by "Albatross" field number) from Fowler and Bean (1929: 238). "Dark brown, sometimes with slate; on fading side shows narrow brown lines with blue-white interspaces as in *Ctenochaetus strigosus*. Breast from pectoral base downward washed orange brown. Caudal spine with bright orange socket. Orange blotch before and behind pupil. Dull obscure orange stripe from eye through nostrils across frontal region. No shoulder blotch. Dorsal slate-gray or almost black basally, and in alcohol few narrow bars appear on hind terminal portion. Anal like dorsal, without dark base and edge narrowly bright blue. Caudal slate, without white tip but white band across base. Pectoral slate, tips somewhat olive yellow. Ventral slate, with slight yellowish dash at tips of last rays."

Color in life of paratype from Buang Bay, Talajit Island from Fowler and Bean (1929: 240): "Body very finely striped with purplish blue and olive. Front and side of head brown becoming blackish on vertical flap. Very short dark blotch behind upper angle of gill opening. Breast mostly dusky, also with orange shades. Fins dull violaceous, dorsal edge somewhat purplish with submarginal translucent bar; anal margin bright purple. White band across caudal base. Caudal spine with orange socket. Paired fins olive or black, without marks or color variation."

Color (in alcohol) brown with about 55 slightly wavy bluish gray longitudinal lines on body (faded in some specimens) which tend to converge posteriorly on caudal spine; a dark brown bar (1.3 eye diameters in length, in the holotype) on shoulder region which is restricted in width as it passes upper end of gill opening; shoulder bar tilted downward so that a line bissecting it passes from the center of the eye to the base of the 18th anal ray; caudal fin yellowish brown with a chalky white bar at base; dorsal fin yellowish brown with a dark brown band at base (broader posteriorly) and an indistinct narrow dark outer margin; anal fin grayish brown with a faint bluish white band at base and an indistinct narrow dark outer margin; pectoral fins yellowish brown; pelvic fins grayish brown; socket of caudal spine and a margin around the socket as wide as half the width of the spine orange-brown.

The shoulder blotch in this species is not black as in *Acanthurus gahhm* and *Acanthurus maculiceps* but dark brown or orange-brown. On some specimens it can be perceived only with difficulty.

Acanthurus auranticavus appears to be most closely related to *Acanthurus maculiceps* from which it differs primarily in shape and color of the shoulder blotch and lack of pale spots on the head; there is no large pale area on the pectoral fin, nor are there prominent bands in the dorsal and anal fins. Also the posterior gill rakers are more numerous in *A. auranticavus*.

The species is named *auranticavus* in reference to the orange socket of the caudal spine.

I have seen specimens only from the Philippine Islands and the East Indies.

Acanthurus grammoptilus Richardson
Figs. 2*v*, 20

Acanthurus grammoptilus Richardson (1843:

176) (Port Essington, N. Australia); Bleeker (1855: 11) (van Diemensland, N. Australia); Günther (1861: 335); Macleay (1878: 354) (Port Darwin, N. Australia); Macleay (1881: 528).

Hepatus nigrofuscus. Fowler and Bean (in part) (1929: 237) (Mansalay, Mindoro, Philippine Islands).

Dorsal rays VIII or IX (one specimen with VIII, four with IX), 25 or 26; anal rays III, 23 or 24; pectoral rays 16 or 17; anterior gill rakers 16 to 18; posterior gill rakers 21 to 23; a 93 mm. specimen has 14 upper and 18 lower teeth; a 205 mm. specimen has 18 upper and 20 lower teeth; a 245 mm. specimen has 18 upper and 20 lower teeth. All counts based on five specimens from Arnhem Land, northern Australia.

Body depth varying from 1.9 in standard length of a 93 mm. specimen to 2.5 in a 245 mm. specimen; caudal concavity 6.3 to 7.7 in standard length; head length 3.4 to 3.7 in standard length; pectoral fin 3.3 to 3.4 in standard length; pelvic fin 3.6 to 4.3 in standard length; length of snout 4.4 to 4.5 in standard length; length of longest dorsal ray 5 to 5.5 in standard length; interorbital space 3.1 to 3.2 in head length; diameter of eye 3.5 in head length of 93 mm. specimen, 5.2 in head length of 245 mm. specimen.

Color (in alcohol) of 245 mm. Arnhem Land specimen brown with narrow light brown longitudinal undulating lines faintly visible on the sides; caudal spines surrounded by a very dark brown area which extends anterior to the spine a distance greater than one eye diameter; base of caudal fin white; rest of fin brown except posterior margin which is narrowly pale; pectoral fin with outer one-third pale, basal two-thirds brown; a light brown area behind eye, outlined by a narrow dark line; five acuminate light brown bands projecting forward from eye and separated by dark brown lines; remainder of head brown with pale brown spots; dorsal and anal fins brown with a narrow dark brown border and traces of narrow dark brown bands in distal part of soft portion of these fins; five narrow dark brown longitudinal bands barely visible in spinous part of dorsal fin; a dark brown band at base of dorsal fin; pelvic fins brown; opercular membrane dark brown. At the upper end of the gill opening there is a faint dark brown elongate blotch which extends posteriorly a distance almost equivalent to an eye diameter.

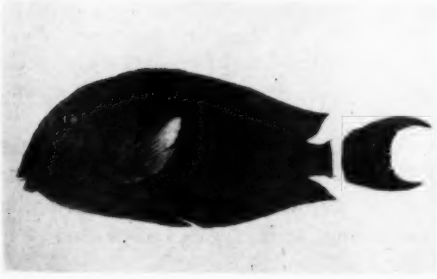


FIG. 20. *Acanthurus grammoptilus*. 245 mm. specimen, Arnhem Land, Australia. Photograph of preserved specimen by Frederick M. Bayer, United States National Museum.

The 93 mm. Arnhem Land specimen differed from the above in having fewer lines on the body, a wider pale posterior border to the caudal fin (about one-third pupil diameter in width), a narrower dark margin around the caudal spine which does not extend anterior to spine, more prominent bands in the dorsal and anal fins, and no dark brown band at the base of the dorsal fin. The color of this specimen in life (from field notes of R. R. Miller who collected the Arnhem Land specimens in 1948) was brown with a white band across the base of the caudal fin and a white posterior margin to the fin. Rust-colored spots, blotches, and wavy lines were present on the head and nape; the pectoral fin was yellowish, and there was a narrow blue margin on the anal fin.

A. C. Wheeler has kindly provided information on two of Richardson's specimens (actually half skins) of *A. grammoptilus*, the larger of which (labelled Coral Bay, Port Essington, Nov. 1840, No. 13 and bearing

British Museum No. 1843.6.15.38) is 191 mm. in standard length and evidently formed the basis for Richardson's description. Günther (1861: 335) listed these skins as types. I designate the larger as lectotype.

Richardson's description plus data from Wheeler to the effect that the larger specimen has a depth of 86 mm., 18 or 19 teeth in the jaws, inconspicuous dark streaks in the dorsal and anal fins, a dark area around the caudal peduncle spine, faint longitudinal lines on the body, no black spot at axil of dorsal or anal fins (Günther was in error in reporting these), and a pectoral fin which is darker basally leave no doubt that the species is valid and that the Arnhem Land specimens which I examined are the same.

A 204 mm. specimen in the United States National Museum from Mindoro, Philippine Islands (misidentified as *Hepatus nigrofuscus* by Fowler and Bean, 1929) appears to be *Acanthurus grammoptilus*. A color note given by Fowler and Bean (1929: 239, "Albatross" No. 6167) is as follows: "No trace of black shoulder mark. More or less orange below caudal spine. Dorsal and anal edged blue. Caudal with very narrow pale edge behind. Pectoral edge yellow." In spite of word to the contrary, there is a faint dark brown shoulder mark. It extends posteriorly from the upper edge of the gill opening a distance equivalent to about one and one-half eye diameters. The mark is not black and could have been overlooked in the field. Surrounding the caudal spine and projecting anterior to it is a reddish brown area. This area is rounded anteriorly like the comparable dark brown region in front of the caudal spine of the large Arnhem Land specimen. The outer one-fourth of the pectoral fin is pale. There is a dark brown band at the base of the dorsal fin and a narrow dark brown margin. The margin of the anal fin is dark blue.

Counts of this specimen are: D IX, 26; A III, 24; P 17; anterior gill rakers 22; posterior gill rakers 24; 17 upper teeth; 20 lower teeth (the end ones tiny).

An Arnhem Land specimen of the same length as the Philippine one provided a basis for comparison of proportional measurements (although the Philippine specimen is a male with the typical highly convex forehead and the Arnhem Land one a female). The Philippine fish has a shorter body (depth 2.2 in standard length, instead of 2.4), a shorter head (3.9 in standard length instead of 3.4), a shorter snout, a longer caudal spine, and a smaller eye. With so few specimens available and the differing sex of the two in question, it is difficult to assess these differences. Even if it could be demonstrated that the measurements of the Philippine specimen are not within the range of variability of Australian *A. grammoptilus*, the problem of deciding whether the differences are subspecific and reflect the geographic separation of the Philippines from Australia would still remain unsolved. In view of the similarity in color pattern, I prefer to regard the Philippine and Arnhem Land specimens as conspecific.

McCulloch (1918) erroneously used the name *grammoptilus* for the species *Acanthurus dussumieri*. Fowler and Bean (1929) applied the name to specimens of *A. dussumieri* and *A. xanthopterus*.

Acanthurus doreensis Cuvier and Valenciennes may be a specimen of *A. grammoptilus* with abnormal fin ray counts (see discussion of this doubtful species on page 226).

Acanthurus dussumieri Cuvier and Valenciennes
Figs. 1*b*, 2*w*, Pl. 3

Acanthurus Dussumieri Cuvier and Valenciennes (1835: 201) (Mauritius).

Acanthurus undulatus Cuvier and Valenciennes (1835: 205) (Indian Ocean); Günther (1861: 335).

Acanthurus Lamarrii Cuvier and Valenciennes (1835: 236) (Mauritius).

Acanthurus dussumieri Günther (1861: 335); Günther (1873: 112, pl. 14, fig. 3) (Hawaiian Islands); Sauvage (1891: 337) (Ma-

dagascar); Steindachner (1901: 493) (Honolulu); Jordan and Jordan (1922: 65) (Hawaiian Islands); Herre (1927: 425, pl. 14, fig. 3) (Philippine Islands); de Beaufort (1951: 155).

Acanthurus matoides Var. *b.* Playfair *in* Playfair and Günther (1866: 56) (Zanzibar).

Rhombotides Dussumieri Bleeker *in* Bleeker and Pollen (1874: 96) (Mauritius).

Rhombotides Lamarrii Bleeker *in* Bleeker and Pollen (1874: 96) (Mauritius).

Teuthis dussumieri Jordan and Evermann (1902: 357) (Formosa); Jenkins (1903: 477) (Honolulu).

Hepatus dussumieri Jordan and Evermann (1905: 390, fig. 169) (Hawaiian Islands); Jordan and Seale (1906: 351); Aoyagi (1943: 214, text fig. 54, pl. 5, fig. 14) (Riu Kiu Islands).

Teuthis grammoptilus. McCulloch (1918: 92, pl. 28) (Clarence River and Masthead Island, New South Wales).

Hepatus bariene. Fowler (1928: 270, pl. 31, fig. C) (Hawaiian Islands); Fowler and Bean (in part) (1929: 222) (Philippine Islands).

Hepatus grammoptilus. Fowler and Bean (in part) (1929: 225) (Philippine Islands and East Indies).

Acanthurus bariene. Smith (in part) (1949: 240, pl. 33, no. 613) (east coast of Africa south to Delagoa Bay).

Dorsal rays IX (one specimen found with VIII), 25 to 27; anal rays III, 24 to 26; pectoral rays 16 or 17 (usually 17); anterior gill rakers 22 to 26; posterior gill rakers 23 to 27 (see Table 20); a 48 mm. specimen has 14 upper and 14 lower teeth; a 61 mm. specimen has 16 upper and 18 lower teeth; a 94 mm. specimen has 17 upper and 18 lower teeth; a 132 mm. specimen has 19 upper and 20 lower teeth; a 325 mm. specimen has 20 upper and 22 lower teeth.

Depth of body (in specimens 110 to 214 mm. in standard length) about 1.9 in standard length (nearly 2.1 in specimens greater than 300 mm. in standard length); caudal concavity varies from 14 in standard length in a 110 mm. specimen to about 7 to 9 in specimens 167 to 214 mm. in standard length to about 5 or less in specimens over 300 mm. in standard length; length of snout 4.2 to 4.6 in standard length; length of caudal spine 3 to 5 in head length (relatively longer in larger specimens); diameter of eye 3.4 in head length of 110 mm. specimen, 4 in head length of 214 mm. specimen, and 4.7 in 300 mm. specimen.

TABLE 18
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus dussumieri* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	25	26	27	24	25	26
Mauritius		3			3	
Philippine Islands	2	8	2	1	10	1
Formosa		2			2	
Okinawa		1		1		
Hawaiian Islands	4	10	3	2	10	5

Color (in alcohol) light brown with numerous, narrow, longitudinal, slightly wavy, purplish or bluish gray lines on body; similar but broader and more irregular lines on head (these and the body lines may fade in preserved specimens); a pale brown (yellow in life) band about as wide as the pupil diameter extending anterodorsally from eye and often meeting a comparable band from other side midway in interorbital space; posterior edge of eye margined with a pale brown (yellow in life) area; caudal spine largely covered by a cream sheath; socket of caudal spine surrounded by a black area about three times as high as maximum width of caudal spine; caudal fin light brown basally and on lobes, darker in major median portion (deep blue in life) with numerous small brownish black spots; dorsal and anal fins of adults light yellowish brown (yellow in life) with traces of about two or three longitudinal dark lines posterodistally (absent in large adults); a

pale bluish gray line at base of dorsal and anal fins; pectoral fins light yellowish brown; pelvic fins brown; opercular membrane black.

Acanthurus dussumieri has at times been confused with *A. xanthopterus* and *A. mata*. Adults of *A. dussumieri* may be readily recognized by the black spots on the caudal fin, the white caudal spine sheath and black area around the caudal spine, lack of a distinct series of longitudinal dark bands from base to margin of dorsal and anal fins, and the presence of purplish longitudinal lines on the body. In small specimens, however, there are longitudinal dark bands from base to margin of the dorsal and anal fins (eight in the soft dorsal of a 110 mm. specimen), the spots on the tail are less distinct or absent, and the sheath of the caudal spine is not as contrastingly pale. The lines on the body are broader and hence fewer in number; in fresh specimens the linear pattern on the body remains as the best color character for separating *A. dussumieri* from the other two species, but, as mentioned, the lines may fade on preserved specimens. The larger eye and higher gill raker counts of *A. dussumieri* are then very helpful in distinguishing this species.

I have seen specimens of *A. dussumieri* or know of definite records of this species from the east coast of Africa, islands in the Indian Ocean, Australia, East Indies, Formosa, Philippine Islands, Riu Kiu Islands and probably also southern Japan, and the Hawaiian Islands. The latter group of islands represents the sole locality for the species in Oceania. If this were ultimately found to be the true range of the species, it would be supporting evidence that pioneer fishes of the Hawaiian Archipelago arrived via the extension of the Kuroshio Current and the North Pacific Current from islands to the west of Hawaii, rather than from reefs and small islands south of Hawaii by way of a branch of the north equatorial current as postulated by Herre (1940). I do not advocate, however, that such an indication from one or even several species should form the basis for the assumption that the entire Hawaiian fish fauna had such a mode of origin.

Jordan and Seale (1906: 351) stated that *Hepatus dussumieri* is the commonest species of the genus about the Hawaiian Islands. In the same work these authors listed *Hepatus sandvicensis* (= *Acanthurus triostegus sandvicensis*) as the most abundant species of the genus about Hawaii. I concur in their latter statement. Although *Acanthurus dussumieri* is a very common species in the Hawaiian Islands, it is probably exceeded in abundance by *Acanthurus nigrofuscus* and perhaps other species as well as *Acanthurus triostegus*. It occurs both in bays and in exposed reef areas.

A. dussumieri is one of the three largest species of *Acanthurus;* it reaches a standard length of at least 400 mm.

Acanthurus xanthopterus Cuvier and Valenciennes
Fig. 2*x*, Pl. 3

Acanthurus xanthopterus Cuvier and Valenciennes (1835: 215) (Seychelles); Valenciennes (1837: pl. 71, fig. 2); Cantor (1849: 1191, pl. 4) (Pinang, Malaya).

Acanthurus matoides. Bleeker (1850*a:* 12) (Batavia, Java); Günther (1861: 330) (East Indies and Fiji Islands); Day (1865: 126) (seas of India); Playfair *in* Playfair and Günther (1866: 56) (Zanzibar) (as Variety *a*); Klunzinger (1871: 508) (Red Sea); Day (1876: 205) (seas of India); Day (1889: 141); Jordan and Snyder (1907: 217) (Hawaiian Islands); Jordan and Jordan (1922: 65) (Honolulu); Vinciguerra (1926: 567) (Sarawak, Borneo); Herre (1927: 430, pl. 16, fig. 3) (Honolulu and Philippine Islands); Herre (1936: 243) (Tahiti and Solomon Islands); de Beaufort (1951: 156) (East Indies).

Rhombotides matoides Bleeker (1863*b:* 235) (Ternate, East Indies).

? *Acanthurus matoides* Kner (1865–67) (India).

Acanthurus blochii. Günther (1873: 109, pl. 69, fig. B) (Indo-Pacific); Waite (1897: 188) (Funafuti, Ellice Islands).

Teuthis crestonis Jordan and Starks *in* Jordan (1895: 485, pl. 47) (Mazatlan, Mexico); Jordan and Evermann (1898: 1692); Jordan and Evermann (1900: pl. 256, no. 628); Gilbert and Starks (1904: 151) (Panama Bay).

Teuthis mata. Seale (1901: 107) (Guam).

Teuthis argenteus. Jordan and Fowler (1902: 553) (Okinawa and Japan).

Teuthis güntheri Jenkins (1903: 477, fig. 29) (Honolulu).

Teuthis xanthopterus Jenkins (1903: 477) (Hawaiian Islands).

Hepatus matoides. Jordan and Evermann (1905: 387) (Honolulu); Jordan and Seale (1906: 352) (Samoa); Jordan and Seale (1907: 34) (Philippine Islands).

Hepatus guntheri Jordan and Evermann (1905: 388, fig. 168).

Hepatus xanthopterus Jordan and Evermann (1905: 389) (Honolulu).

Hepatus aquilinus Jordan and Seale (1906: 353, fig. 66) (Apia, Samoa).

? *Teuthis guentheri* Bamber (1915: 482) (Red Sea).

Hepatus crestonis Snodgrass and Heller (1905: 403) (Cocos Island off Costa Rica); Fowler (1916: 411) (Panama Bay).

Acanthurus umbra. Jordan and Jordan (in part) (1922: 65) (Hawaiian Islands).

Teuthis nigrofuscus. Barnard (1927: 779) (Natal coast, Africa).

Hepatus fuliginosus. Fowler (1927: 17) (Fanning Island, Line Islands); Fowler (in part) (1928: 266, pl. 31, fig. B) (Oceania); Fowler and Bean (in part) (1929: 211) (Hawaiian Islands); Fowler (1934: 480) (Durban, Natal); Fowler (1938: 102, 202, 211, 230) (Takaroa in the Tuamotu Archipelago, Christmas and Fanning Islands, and Honolulu).

Acanthurus crestonis Meek and Hildebrand (1928: 782) (west coast of Panama).

? *Hepatus nigrofuscus*. Fowler (1928: 267) (Christmas Island, Oceania).

Hepatus elongatus. Fowler and Bean (in part) (1929: 213) (Hawaiian Islands and Samoa).

Hepatus bariene. Fowler and Bean (in part) (1929: 222) (Hawaiian Islands).

Acanthurus grammoptilus. Fowler and Bean (in part) (1929: 225) (Philippine Islands and East Indies).

Acanthurus fuliginosus. Schultz (1943: 166) (Phoenix and Samoa Islands); Smith (1949: 240, pl. 33, no. 611) (east coast of Africa south to Durban); Schultz and Woods *in* Schultz *et al.* (1953: 637) (Guam).

Teuthis fuliginosus. Fowler (1949: 102).

Dorsal rays IX (two specimens were found with VIII), 25 to 27; anal rays III, 23 to 25; pectoral rays 16 or 17 (usually 17); anterior gill rakers 16 to 24; posterior gill rakers 17 to 22 (see Table 20); a 37 mm. specimen has 12 upper and 14 lower teeth; a 59 mm. specimen has 13 upper and 15 lower teeth; a 97 mm. specimen has 15 upper and 16 lower teeth; a 126 mm. specimen has 17 upper and 18 lower teeth; a 196 mm. specimen has 18 upper and 20 lower teeth; a 320 mm. specimen has 18 upper and 21 lower teeth.

TABLE 19

VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus xanthopterus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	25	26	27	23	24	25
Durban, S. Africa		3	2		2	3
Red Sea		1			1	
Mauritius		1	1		1	1
East Indies		2	2		2	2
Philippine Islands	1	4	2	1	3	3
Solomon Islands	1	1			2	
Mariana Islands	1	5	1		7	
Gilbert Islands		1	1		1	1
Phoenix and Samoa Islands		5	2		5	2
Line Islands		3			1	2
Jarvis Island		1				1
Hawaiian Islands	2	3	2		6	1
Galapagos Islands		1				1
W. Mexico and W. Panama	2	5	1		4	4

Body depth varies from 1.95 in standard length of a 127 mm. specimen to 2.25 in a 423 mm. specimen; caudal concavity 7 in standard length of a 127 mm. specimen, 5 in standard length of a 196 mm. specimen, and 4.6 in a 320 mm. specimen; length of snout 4.8 in standard length of 127 mm. specimen, 4.95 in 196 mm. specimen, and 5.3 in 423 mm. specimen; diameter of eye 3.9 in head length of 127 mm. specimen, 4.1 in 173 mm. specimen, 4.4 in 196 mm. specimen, 4.7 in 310 mm. specimen, and 5.6 in 415 mm. specimen; length of caudal spine 5.5 in head length of 127 mm. specimen, 5 in 173 and 196 mm. specimens, 4.4 in a 310 mm. specimen; longest dorsal ray 4.4 in standard length of 127 mm. specimen, 5 in standard length of 196 mm. specimen, and 5.7 in standard length of a 320 mm. specimen.

A 196 mm. specimen of *A. xanthopterus* was speared by the author in the lagoon at Tarawa Atoll, Gilbert Islands, at a depth of 39 feet and provided the following description of the life colors: while the fish was still alive, the body color changed back and forth from uniform purplish gray to a color phase in which extremely irregular dark gray lines (about two scales in width) alternated with light blue-gray lines of about the same width; extreme posterior part of caudal peduncle and base of caudal fin dull white; remainder of caudal fin purplish gray; dorsal and anal fins yellowish gray basally, shading to dull yellow distally, with four longitudinal broad blue bands; a narrow bluish gray band at base of dorsal and anal fins; outer margin of dorsal and anal fins narrowly black; basal two-thirds of pectoral fin dusky, outer one-third yellow except extreme distal part which is hyaline; pelvic rays purplish gray, membranes dusky yellow; lower two-thirds of eye margined with diffuse yellow; a region of dull yellow extending directly anterior from eye a distance equivalent to about one eye diameter; a lesser posterior extension of dull yellow from lower corner of eye.

Preserved specimens are usually a uniform grayish brown; only occasional specimens retain the tortuous line pattern on the body. The bands in the dorsal and anal fins may fade.

The most important color characters of *A. xanthopterus*, for separating the species from *A. mata* and *A. dussumieri*, are the number of longitudinal bands in the dorsal and anal fins, the lack of narrow, nearly straight, longitudinal lines or rows of spots on the body, the lack of a black region around the caudal spine (although the region around the spine may be slightly darker than the color of the body), and (in adults) the abrupt pale color of the outer one-third of the pectoral fin. There are no small black spots on the caudal fin, no whitish caudal spine sheath, and no definite pale band which crosses or nearly crosses the interorbital space, all characteristic color markings of *A. dussumieri*.

Apart from color, *A. xanthopterus* is most distinctive in its possession of a small caudal spine, small eye (not useful in separation from *A. mata*), and low gill raker counts (see Table 20).

In Fowler and Bean (1929: 227) there is a color description of specimens bearing "Albatross" numbers 8509 and 8510 which these authors identified as *Hepatus grammoptilus*. These specimens and probably others are *Acanthurus xanthopterus*. The description of the color of specimens with the numbers 7803, 7804, and 7806, however, apply to *Acanthurus dussumieri*.

The specific names most commonly used for *A. xanthopterus* are *matoides* and *fuliginosus*. *Acanthurus matoides* Cuvier and Valenciennes is a synonym of *Acanthurus nigrofuscus*. *Acanthurus fuliginosus* Lesson was described as a uniform brown fish with a blue line on the chin. It is very unlikely that this species is the same as *A. xanthopterus* (see page 160).

Günther (1873: 109, pl. 69, fig. B) misidentified *A. xanthopterus* as *Acanthurus blochii*. *Acanthurus blochii* Cuvier and Valenciennes is probably a synonym of *Acanthurus mata* (Cuvier).

Fowler and Bean (1929: 214) placed *Hepatus aquilinus* Jordan and Seale in the synonymy of *Hepatus elongatus*. I examined the type of *H. aquilinus*, and it is a moderately large specimen of *Acanthurus xanthopterus*.

I am unable to distinguish *Acanthurus crestonis* (Jordan and Starks) of the western coast of Mexico and Central America from *Acanthurus xanthopterus;* thus I have placed the former in the synonymy of the latter.

The type of *Acanthurus xanthopterus*, a 162 mm. specimen, is in the Paris Museum (No. 162).

A. xanthopterus is probably the largest species of *Acanthurus*. It may exceed 500 mm. in standard length. It occurs commonly in bays and lagoons, but may also be taken in outer reef areas. At least in the adult stage it appears to be more characteristic of deeper water than most surgeon fishes. Trap fishermen in the Hawaiian Islands refer to the species as deep water *pualu;* they call *A. mata* merely *pualu.*

A. xanthopterus is a wide-ranging species. It is known from East Africa to West Mexico.

Acanthurus mata (Cuvier)

Figs. 1*d*, 2*y*, Pl. 3

? *Chaetodon nigricans*. Bloch (1787: 184, pl. 203).

? *Acanthurus nigricans*. Bloch and Schneider (1801: 211) (Arabian Sea).

? *Acanthurus nigricans*. Rüppell (1828: 57) (Red Sea).

Chaetodon meta Cuvier (1829: 224) (after Russell, error for *mata*).

Acanthurus mata Cuvier and Valenciennes (1835: 202); Schultz and Woods *in* Schultz *et al.* (1953: 639) (Marshall Islands).

TABLE 20

VARIATION IN GILL RAKER COUNTS OF SPECIMENS OF *Acanthurus dussumieri*, *Acanthurus xanthopterus*, AND *Acanthurus mata* FROM DIFFERENT LOCALITIES

SPECIES AND LOCALITY	ANTERIOR GILL RAKERS											POSTERIOR GILL RAKERS										
	16	17	18	19	20	21	22	23	24	25	26	17	18	19	20	21	22	23	24	25	26	27
A. dussumieri																						
Mauritius									1										1			
Philippine Islands							1	2	1	1								1	2		2	
Hawaiian Islands								3	3		1								2	3	1	1
A. xanthopterus																						
Durban, S. Africa					1				1						1	1						
Red Sea			1											1								
Mauritius		1					1					1			1							
Philippine Islands		1	4	1										1	3	2						
Solomon Islands				1			1							1	1							
Mariana Islands	1	2	3											4	1	1						
Gilbert Islands			1			1								1	1							
Phoenix and Samoa Islands		1	3										1		1		1					
Line Islands		2		1											1	2						
Hawaiian Islands		1	3	3	1	1	1					1	1	2	4	2						
Galapagos Islands						1									1							
W. Mexico and W. Panama		1	2		2		1						1	3	1	1						
A. mata																						
Durban, S. Africa					1												1					
Mariana Islands						1														1		
Marshall Islands					1	1													1	1		
Wake Island							2													1		
Tuamotu Archipelago					1																1	
Hawaiian Islands					2	4	9	3		1								5	5	8	1	

Acanthurus rasi Cuvier and Valenciennes (1835: 203) (Pondichéry, India).
? *Acanthurus Blochii* Cuvier and Valenciennes (1835: 209) (Mauritius).
Acanthurus nigro-fuscus. Günther (1861: 331) (Ceylon and Ambon, East Indies).
Acanthurus blochi Streets (1877: 68) (Harbor of Honolulu).
Acanthurus umbra. Jordan and Jordan (in part) (1922: 65) (Hawaiian Islands); Schultz (1943: 165) (Tutuila Island, Samoa Islands).
? *Hepatus mata* Fowler (1928: 267) (Society Islands).
Hepatus bariene. Fowler and Bean (in part) (1929: 222) (Philippine Islands).
? *Teuthis mata* Fowler (1949: 102).
Acanthurus sp. two Harry (1953: 150) (Raroia, Tuamotu Archipelago).
Acanthurus lineolatus. Smith (in part) (1949: 240, pl. 33, no. 609) (east coast of Africa south to Durban).

Dorsal rays IX, 25 to 27; anal rays III, 24 or 25; pectoral rays 17; anterior gill rakers 20 to 25; posterior gill rakers 23 to 26 (see Table 20); a 47 mm. specimen has 14 upper and 14 lower teeth; an 84 mm. specimen has 16 upper and 16 lower teeth; a 101 mm. specimen has 16 upper and 18 lower teeth; a 153 mm. specimen has 18 upper and 19 lower teeth; a 203 mm. specimen has 18 upper and 20 lower teeth; a 247 mm. specimen has 20 upper and 20 lower teeth.

TABLE 21
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus mata* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	25	26	27	23	24	25
Durban, S. Africa		1				1
Mariana Islands	1				1	
Marshall Islands	1	1			2	
Wake Island			1			1
Tuamotu Archipelago		1			1	
Hawaiian Islands	4	9	2	1	12	2

Depth of body 1.9 to 2.1 in standard length; caudal concavity varies from 10 in standard length of a 151 mm. specimen to 8.2 in a 191 mm. specimen, and to 6.2 in a 292 mm. specimen; length of snout 4.3 to 4.5 in standard length; eye diameter 3.1 in head length of 47 mm. specimen, 4.2 in head length of 151 mm. specimen, and 5 in head length of 292 mm. specimen; length of caudal spine 3 to 4.4 in head length.

Color (in alcohol) brown (the rows of small spots on the sides are usually lost in preservative); base of caudal fin abruptly pale, remainder of fin brown (dark blue in life with about six indistinct, vertical, slightly wavy, dark lines); dorsal fin with eight or nine narrow longitudinal dark bands, and anal fin with five or six similar bands (the bands in the fins are often not visible in preserved specimens); pectoral fins entirely brown; pelvic fins brown; dark brown to black region around caudal spine about twice as high as maximum width of spine; the most prominent marking on head in life is an elongate yellow spot (about half the size of the eye) which extends posteriorly and slightly upward from lower edge of eye; this is usually lost in preservative.

A. mata is distinct from *A. xanthopterus* in having eight or nine instead of four or five longitudinal dark bands in the soft portion of the dorsal fin, a uniform brown pectoral fin (the outer one-third of the pectoral fin of *A. xanthopterus* is pale), a more definite dark area around the caudal spine, a larger caudal spine, and higher gill raker counts.

Adult *A. mata* may be distinguished from adult *A. dussumieri* by lacking black caudal spots, white caudal spine sheath, and a pale transverse band on the interorbital, and having numerous longitudinal bands in the dorsal and anal fins. Fresh specimens of subadult *mata* may be best distinguished from *A. dussumieri* of about the same size (which may have eight or nine bands in the dorsal fin and five or six in the anal like *mata*) by the linear pattern of the body. Lines of small pale spots occur on *A. mata;* the lines on the body

of *A. dussumieri* are unbroken. On preserved specimens the body color of either species may be uniform brown; the larger size of the eye of *dussumieri* is then the best means of separation.

When viewed underwater, *A. mata* appears almost black except for the base of the caudal fin which is usually white. The degree of whiteness of the caudal band is variable. The band is generally dull white or gray on captive fish. This appears to be true of all of the species of *Acanthurus* which have a white or light gray caudal base.

The blue and yellow colors of specimens of *A. mata* collected from bays were noticeably duller than these colors on specimens from clear outer reef areas.

There is no type specimen of *Acanthurus mata*. The name and description originated with the prelinnaean author Russell whose work I have not seen. Cuvier (1829: 224) cited Russell when he listed *Chaetodon meta* among the surgeon fishes in his Règne Animal. This appears to be an error for *mata*, for all subsequent authors, some of whom have referred to Russell, have spelled the name *mata*. Cuvier and Valenciennes (1835: 202) gave a brief description based on Russell. Their reference to the similarity to *Acanthurus dussumieri*, the dark body color with blue on the head and elsewhere, and a size up to 18 inches constitutes the principal basis for my calling the species, as here defined, *Acanthurus mata*.

Schultz and Woods (1953: 640) correctly assigned the name *Acanthurus mata* to two large specimens (280 and 310 mm.) from the northern Marshall Islands. These authors proposed that the name *mata* be restricted to Plate 48, Figure 1 of Day (1876); however, this figure appears to be *Acanthurus nigrofuscus* (Forskål).

I have been unable to identify or can only tentatively identify many of the records in the literature which may be *A. mata* because of insufficient descriptive information. To my knowledge, the species has never been figured. Most of the unquestioned names in my synonymy for the species are based on the examination of specimens. *Acanthurus blochi* of Streets (1877: 68), for example, are small specimens of *A. mata*. Fowler and Bean (1929: 246) were in error in considering these as *Hepatus glaucopareius*.

Although the color seems a little different, the species from Africa identified as *Acanthurus lineolatus* by Smith (1949: 240, pl. 33, fig. 609) is probably *A. mata*. A 71 mm. specimen kindly loaned by Smith proved to be *Acanthurus bleekeri*, however.

Acanthurus monroviae Steindachner
Figs. 2*z*, 21

Acanthurus phlebotomus. Troschel (*non* Cuvier and Valenciennes) (1866: 227) (Cape Verde Islands).

Acanthurus Monroviae Steindachner (1876: 160) (Monrovia, Liberia).

Acanthurus chirurgus. Peters (1876: 246) (Victoria, Cameroon, West Africa).

Acanthurus monroviae Steindachner (1895: 18) (mouth of Messurado River and Cape Mount, Liberia); Metzelaar (1919: 256) (Senegal Coast, West Africa).

Teuthis munroviae Gill (1896: 188) (error for *monroviae*).

Dorsal rays IX, 25 to 27; anal rays III, 24 to 26; pectoral rays 17; anterior gill rakers 16 or 17; posterior gill rakers 16; an 88 mm. specimen has 12 upper and 14 lower teeth; a 192 mm. specimen has 18 upper and 18 lower teeth. These counts and the measurements given below were obtained from two specimens from Liberia which are in the United States National Museum.

Depth of body 2.0 (in 192 mm. specimen) to 2.2 (in 88 mm. specimen) in standard length; caudal concavity 7.6 (in 192 mm. specimen) to 10.4 (in 88 mm. specimen) in standard length; diameter of eye 3.5 (in 88 mm. specimen) to 4.0 (in 192 mm. specimen) in head length; length of snout 4.9 to 5.2 in standard length; length of longest dorsal

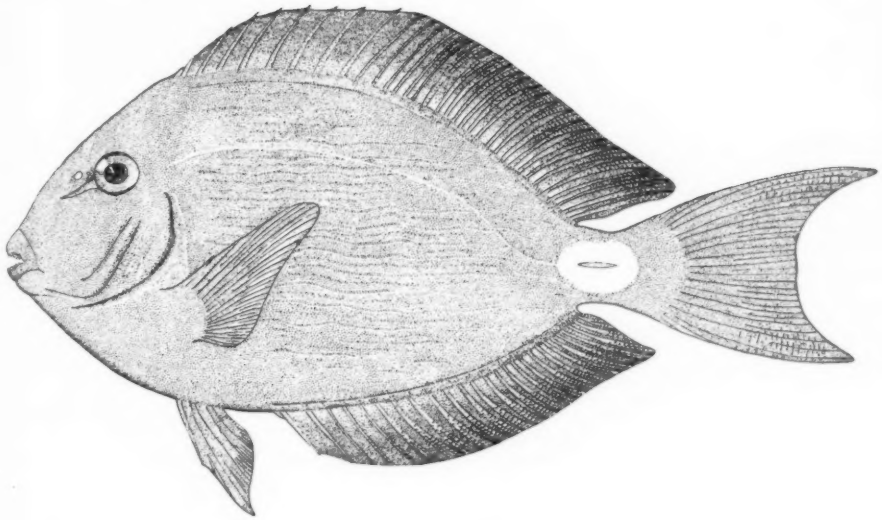


FIG. 21. *Acanthurus monroviae*. 192 mm. specimen, Liberia. Drawing by L. B. Isham, United States National Museum.

ray 4.9 to 5.1 in standard length; length of pectoral fin 3.4 (in 88 mm. specimen) to 3.6 (in 192 mm. specimen) in standard length; length of caudal spine 4.5 to 5.7 in head length.

Color (in alcohol) of 88 mm. specimen brown with a white area (in height slightly less than diameter of eye) around caudal spine; about 15 narrow, dark, undulating lines on side of body; opercular membrane very dark brown; area around edge of upper limb of preopercle very dark brown; median fins very dark brown except extreme margin of central part of caudal fin which is pale; pectoral fin rays dusky except for outer part of lower 11 rays which are pale; pectoral membranes pale; pelvic fins very dark brown. The 192 mm. specimen differs in color in having more numerous and less conspicuous lines on the body, a relatively larger pale area around the caudal spine (in height almost one-third the head length), black median fins except base of dorsal and anal which are brown, and the margin of the preopercle only slightly darker than the rest of the head.

The pale spot around the caudal spine was described as yellow in life. Peters (1876) mentioned a blue border around this yellow area. Both Peters and Steindachner described the lines on the body as blue.

Fowler (1936: 912) erroneously synonymized this species with *Hepatus hepatus* (= *Acanthurus chirurgus*).

Acanthurus monroviae is known only from West Africa.

Acanthurus coeruleus Bloch and Schneider
Figs. 2*aa*, 22

Acanthurus Coeruleus Bloch and Schneider (1801: xxxviii, 214) (Carolina and Havana).

Acanthurus Broussonnetii Desmarest (1823: 26, pl. 3, fig. 1) (Cuba).

Acanthurus caeruleus Cuvier and Valenciennes (1835: 175) (Martinique, Puerto Rico, and Santo Domingo); Castelnau (1855: 25) (Bahia, Brazil); Günther (1861: 336) (West Indies, Caribbean Sea, and Bahia); Poey (1868: 355) (Cuba); Beebe and Tee-Van (1928: 184) (Port-au-Prince Bay, Haiti);

Breder (1929: 221); Beebe and Tee-Van (1933: 179) (Bermuda); Longley and Hildebrand (1941: 155) (Tortugas, Florida).

Acanthurus coeruleus Storer (1846: 112); Lütken (1880: 609, pl. 5, fig. 3) (Antilles); Jordan and Gilbert (1882: 617); Meek and Hildebrand (1928: 782) (Atlantic coast of Panama).

Acanthurus violaceus Castelnau (1855: 25).

Acanthurus brevis Poey (1860: 207) (Cuba); Poey (1868: 355).

Acronurus caeruleatus Poey (1875: 69, pl. 3, figs. 15 to 17 of developing scales) (Cuba).

Acanthurus nigricans. Goode (1876: 41) (Bermuda).

Teuthis coeruleus Meek and Hoffman (1884: 228); Evermann and Marsh (1902: 253, pl. 38) (Puerto Rico).

Teuthis helioides Barbour (1905: 127, pl. 3) (Bermuda).

Hepatus caeruleus Fowler (1916: 405) (Colon, Panama).

Hepatus pawnee Breder (1927: 73, fig. 32) (Glover Reef, British Honduras).

Teuthis caeruleus Nichols and Breder (1927: 134) (New York).

Acanthurus heliodes Beebe and Tee-Van (1933: 179) (error for *helioides*) (Bermuda).

Teuthis (*Rhomboteuthis*) *coeruleus* Fowler (1944*a*: 109, pl. 13, upper left fig.) (Courtown Keys, Caribbean Sea).

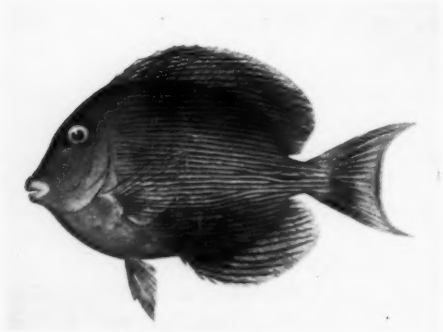


FIG. 22. *Acanthurus coeruleus* (after Jordan and Marsh, 1902).

Acanthurus hepatus. Carvalho (1952: 115, fig.) (Trinidad).

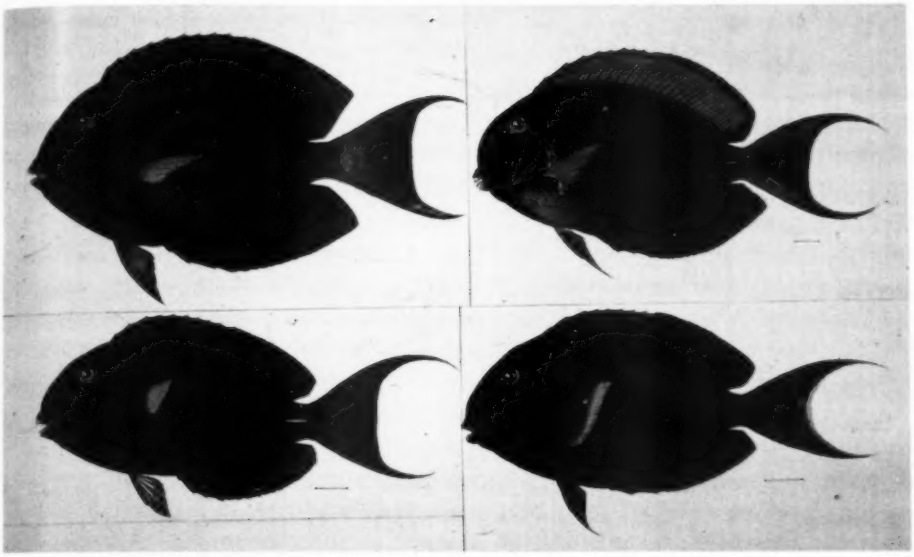
Dorsal rays IX, 26 to 28; anal rays III, 24 to 26; pectoral rays 16 or 17; anterior gill rakers 13 or 14; posterior gill rakers 13 (raker counts from specimens from Bermuda to Brazil); a 38 mm. specimen has 8 upper and 10 lower teeth; an 82 mm. specimen has 10 upper and 12 lower teeth; 90 and 115 mm. specimens have 12 upper and 14 lower teeth; a 235 mm. specimen has 14 upper and 16 lower teeth.

TABLE 22
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus coeruleus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS			ANAL SOFT RAYS		
	26	27	28	24	25	26
Bermuda		2	1		2	1
Florida	1		2	1	2	
West Indies	3	11	2	2	11	3
Brazil		1	1		1	1

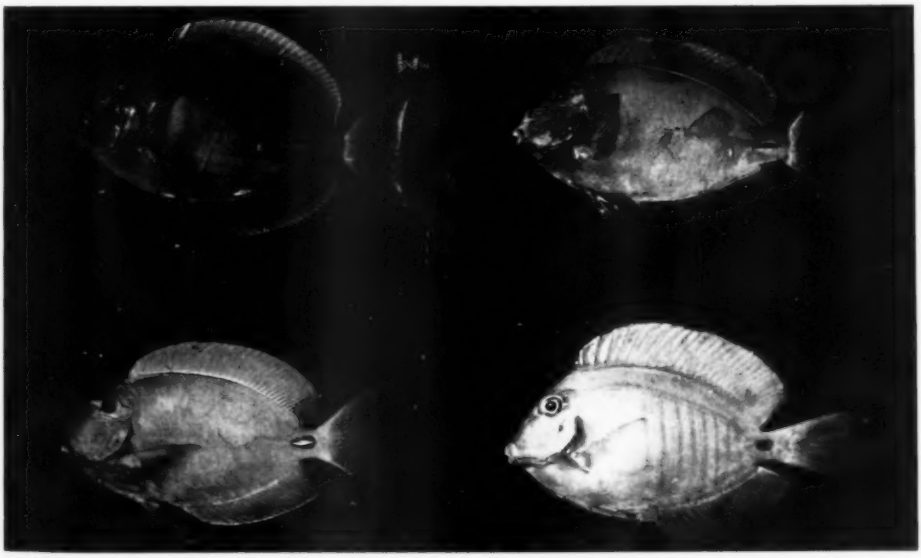
Depth of body 1.7 in standard length; caudal concavity varies from 11.7 in standard length in an 82 mm. specimen to 7.7 in a 115 mm. specimen, to 5.3 in a 178 mm. specimen, and 5.1 in a 235 mm. specimen; caudal spine 6.5 in head length of an 82 mm. specimen, 3.7 in 235 mm. specimen; length of pectoral fin 2.8 to 2.95 in standard length; diameter of eye 3 in head length of an 82 mm. specimen and 4.5 in head length of a 235 mm. specimen.

Color (in alcohol) grayish brown with alternating dark and light, slightly irregular, longitudinal lines on body (the light lines are about three times as broad as the dark); lines on dorsal part of body angle upward to dorsal fin; caudal fin grayish brown with a very narrow pale posterior margin and a dark submarginal band about four times as broad as the pale margin; dorsal fin with about seven dark longitudinal bands in the spinous portion and nine in the soft portion; anal fin with



Acanthurus fowleri. *Acanthurus bariene.*
Acanthurus maculiceps. *Acanthurus gahhm.*

From paintings of the Philippine "Albatross" Expedition, 1909, in the Division of Fishes, United States National Museum. Reproduced by courtesy of Leonard P. Schultz.



A. xanthopterus, 174 mm. specimen, Hawaiian Islands. *A. mata*, 269 mm. specimen, Hawaiian Islands.
A. dussumieri, 255 mm. specimen, Hawaiian Islands. *A. chirurgus*, Florida (pale phase).

(Note scratches and reflections on figures.)

about five longitudinal dark bands; margins of dorsal and anal fins dark brown; pectoral fins pale; pelvic fins dark brown; no dark area around caudal spine; sheath of caudal spine pale.

A 125 mm. specimen speared by the writer at Nassau, Bahamas, provided the following color note: body purplish gray with 26 irregular dark gray longitudinal lines; dorsal and anal fins bright blue with orange-brown longitudinal bands; caudal fin blue, shading to yellowish gray in center; pectoral fins clear yellow; pelvic fins blue; sheath of caudal spine white. Some specimens observed underwater had three vertical pale bars on the body.

Townsend (1929: 19, pl. 21) described and figured three color phases of this species from aquarium observations, a blue, a blue with three or four pale vertical bars, and a creamy white with blue margins on the fins. The latter phase was seldom seen until evening when the fish settled toward a white sand bottom. Longley (1941: 155) observed that the species was very light over a pale sandy bottom.

Longley also observed that the young are clear yellow, and he correctly referred *Teuthis helioides* Barbour to the synonymy of *Acanthurus coeruleus*. He stated that specimens up to 100 or 125 mm. in length may be yellow. His length measure is probably total length. The longest yellow specimen which I have seen is the type of *Teuthis helioides* in the Museum of Comparative Zoology (No. 29053). It is 77 mm. in standard length. The size at which the blue-gray color replaces the yellow is variable. I speared a 31 mm. specimen at Nassau which was blue except for the middle of the caudal fin which was yellow.

The largest specimen of *A. coeruleus* seen by me is a 235 mm. one from Bermuda. Another from Bimini is 234 mm. in standard length.

Lütken (1880: pl. 5, figs. 3, 4, and 5) figured the postacronurus, acronurus, and a 5.7 mm. postlarval specimen of *A. coeruleus*. The postacronurus has three vertical pale bands on the body.

Hepatus pawnee Breder (1927: 73, fig. 32) is apparently the acronurus of *A. coeruleus*, judging from the deep body and the fin ray counts D IX, 27 and A III, 25. It was taken at a night light at Glover Reef, British Honduras.

Fowler (1944*a*: 109) proposed the subgenus *Rhomboteuthis* for *A. coeruleus*. As previously discussed (Randall, 1955*b*), this does not seem justified.

Longley (1941: 155) pointed out that *A. coeruleus* is seen more often well above the bottom than the other two surgeon fishes commonly seen in Florida waters, *A. chirurgus* and *A. bahianus*. He stated that the food of *A. coeruleus* is wholly algal like that of *A. chirurgus* and *A. bahianus* but contains less sand and bottom debris than that of the latter two species. This is consistent with the structure of the stomach of these three species. *A. coeruleus* has a thin-walled stomach, whereas the other two species have heavy-walled, gizzard-like stomachs. Breder and Clark (1947: 295, fig. 1) described the morphology of the digestive tract of *A. coeruleus*.

Acanthurus chirurgus (Bloch)

Figs. 1*b*, 2*bb*, Pl. 3

Chaetodon chirurgus Bloch (1787: 204, pl. 208) (Martinique).

Acanthurus Chirurgus Bloch and Schneider (1801: xxxviii, 214) (Caribbean Sea).

Acanthurus Hepatus. Bloch and Schneider (in part) (1801: 211) (America and Bahama Islands).

Acanthurus chirurgus Lacépède (1802: 546); Cuvier and Valenciennes (1835: 168) (Martinique, Puerto Rico, Cuba, and Brazil); Storer (1846: 112); Günther (in part) (1861: 329) (Caribbean Sea, West Indies, Venezuela, and Brazil); Günther (1869: 238) (St. Helena); Goode (1876: 42) (Bermuda); Jordan and Gilbert (1882: 617); Metzelaar (1919: 256) (both sides of Atlantic).

Acanthurus phlebotomus Cuvier and Valenciennes (1835: 176, pl. 287) (Martinique,

Brazil, Havana, and New York); Storer (1846: 111); Poey (1868: 355) (Cuba).

Acanthurus chirurgicus Castelnau (1855: 24) (Bahia, Brazil).

Acanthurus nigricans. Jordan and Gilbert (1882: 941).

Teuthis hepatus. Meek and Hoffman (1884: 229); Jordan and Evermann (1898: 1691); Evermann and Marsh (1902: 254) (Puerto Rico); Nichols and Breder (1927: 134) (New York); Gudger (1929: 196) (Tortugas, Florida); Fowler (1944*a*: 110, pl. 13, right hand figs.) (Courtown Keys, Caribbean Sea).

Hepatus hepatus. Fowler (1916: 403) (Colon, Panama); Fowler (1936: 912, fig. 385) (West Africa).

Acanthurus hepatus. Meek and Hildebrand (1928: 784) (Atlantic coast of Panama); Beebe and Tee-Van (1928: 185) (Port-au-Prince Bay, Haiti); Breder (1929: 221); Beebe and Tee-Van (1933: 181, col. pl. 4, incorrectly labelled *Acanthurus caeruleus*) (Bermuda); Longley and Hildebrand (1941: 156) (Tortugas, Florida).

Dorsal rays IX, 24 or 25; anal rays III, 22 or 23; pectoral rays 16 or 17; anterior gill rakers 16 to 19; posterior gill rakers 15 to 18 (raker counts from West Indian specimens); 32 mm. and 54 mm. specimens have 10 upper and 12 lower teeth; a 140 mm. specimen has 16 upper and 18 lower teeth; a 184 mm. specimen has 18 upper and 20 lower teeth.

TABLE 23
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus chirurgus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS		ANAL SOFT RAYS	
	24	25	22	23
Massachusetts	1	1	1	1
Bermuda		1	1	
Florida		2		2
West Indies	9	22	10	21
Brazil	1		1	

Depth of body about 2 in standard length; caudal fin emarginate (nearly truncate in young), caudal concavity about 14 to 18 in standard length; length of caudal spine 5 in head length of a 54 mm. specimen, 3.5 in a 165 mm. specimen; length of pectoral fin 3 in standard length; diameter of eye 2.9 in standard length of a 54 mm. specimen, 3.8 in a 184 mm. specimen.

Color (in alcohol) brown, usually with 10 to 12 long vertical dark brown bars visible on side of body; caudal spine enclosed in a very dark brown area, the height of which is about three times the maximum width of the spine; no definite white posterior margin to caudal fin (extreme tips of caudal rays pale, resulting in a very narrow, irregular, white margin); dorsal fin with nine diagonal dark bands in spinous portion (two to seven on each interspinous membrane) and nine or ten in soft portion (these mostly longitudinal); anal fin with four similar bands (the bands in the fins often fade completely in preservative); margins of dorsal and anal fins narrowly dark brown; outer one-third of pectoral fin pale in adult specimens; membranes of pelvic fins very dark brown; opercular membrane black.

The color photograph of *A. chirurgus* from which Plate 3 was reproduced was taken of a specimen collected by the author in a sandy region at Soldier Key, Florida. It is in a pale color phase. Over a dark substrate the species is usually brown as shown in the two lower figures of plate 22 in Townsend (1929). Longley (1941: 156) described the color phases of this species in detail.

The largest specimen seen by me measured 228 mm. It was taken at Panama.

A. chirurgus is probably the most wide-ranging species of *Acanthurus* in the Atlantic, apparently occurring on the coast of West Africa as well as the entire tropical and subtropical regions of the West Atlantic. Its extension into cooler waters of the northeast United States (such as Massachusetts) is probably a result of transport of the larvae by

the Gulf Stream from more southern regions where resident populations are established. The specimens which I have seen from such northern localities have all been juveniles or subadults. The same applies to specimens of *A. coeruleus* and *A. bahianus*. Breder (1929: 222) stated that *A. chirurgus* is the most common species of the family on the Atlantic coast of the United States.

Townsend (1929: 19) reported that this fish lives well in captivity. Although largely herbivorous, specimens were kept as long as five years in the New York Aquarium on a fish and clam diet varied occasionally with seaweed.

Longley (1941: 156) pointed out, and I have verified his observation, that *Acanthurus chirurgus* often swims in small schools with *A. bahianus*.

After first doubting Longley's placing of *Hepatus pawnee* in the synonymy of *Acanthurus hepatus* (= *Acanthurus chirurgus*), Breder (1949: 296) decided he was correct. I believe, however, that *H. pawnee* as figured by Breder (1927: fig. 32) is the acronurus of *Acanthurus coeruleus*. If the fin ray counts D IX, 27; A III, 25 are correct, no other conclusion could be drawn (see Tables 22 to 24).

Many recent authors have applied the name *Acanthurus hepatus* to the species *Acanthurus chirurgus*. Three different species of surgeon fishes of five prelinnaean authors were cited by Linnaeus (1766: 507) under the name *hepatus*. Cuvier and Valenciennes were the first to restrict the name. They used it for the East Indian species of Seba (1734: 104, pl. 33, fig. 3) which is now recognized as the single species in the genus *Paracanthurus*.

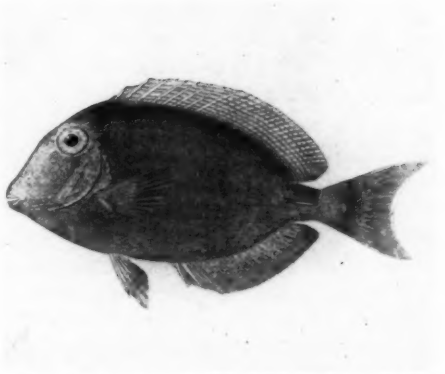


FIG. 23. *Acanthurus bahianus* (after Jordan and Evermann, 1900, retouched).

Acanthurus bahianus Castelnau

Figs. 1*c*, 2*cc*, 23

Acanthurus bahianus Castelnau (1855: 24, pl. 11, fig. 1) (Bahia, Brazil); Meek and Hildebrand (1928: 783) (Atlantic coast of Panama); Beebe and Tee-Van (1928: 184) (Port-au-Prince Bay, Haiti); Breder (1929: 222); Beebe and Tee-Van (1933: 180) (Bermuda); Longley and Hildebrand (1941: 156) (Tortugas, Florida).

Acanthurus tractus Poey (1860: 208) (Cuba); Poey (1868: 356); Jordan and Gilbert (1882: 941).

Acanthurus chirurgus. Günther (in part) (1861: 329) (Caribbean Sea and Brazil).

Acronurus nigriculus Poey (1875: 69, pl. 3, figs. 18 and 19 of scales and caudal fin) (Cuba).

Teuthis tractus Meek and Hoffman (1884: 229).

Teuthis bahianus Jordan and Evermann (1898: 1693) (Key West, Florida and Bahia, Brazil); Jordan and Evermann (1900: pl. 256, no. 629); Evermann and Marsh (1902: 254, fig. 70) (Puerto Rico); Nichols and Breder (1927: 135) (Woods Hole); Gudger (1929: 197) (Tortugas, Florida); Fowler (1944*a:* 110, pl. 13, lower left fig.) (Courtown Keys, Caribbean Sea).

Hepatus bahianus Fowler (1916: 405) (Colon, Panama).

Teuthis coeruleus. Gudger (1929: 196) (Tortugas, Florida).

Dorsal rays IX, 23 to 26; anal rays III, 21 to 23; pectoral rays 15 to 17 (usually 16); anterior gill rakers 20 to 22; posterior gill rakers 17 to 19 (raker counts from West Indian specimens); a 55 mm. specimen has 12 upper and 12 lower teeth; an 85 mm. spec-

imen has 12 upper and 14 lower teeth; a 100 mm. specimen has 14 upper and 16 lower teeth; a 170 mm. specimen has 14 upper and 16 lower teeth.

Depth of body about 2 in standard length; caudal concavity varies from 13.5 in a 68 mm. specimen to 8.3 in a 124 mm. specimen to 4.6 in a 170 mm. specimen; length of caudal spine 3.5 in head length of a 105 mm. specimen, 2.8 in a 155 mm. specimen; length of pectoral fin 3 in standard length of a 105 mm. specimen, 3.5 in standard length of a 155 mm. specimen; diameter of eye 3 in head length of a 105 mm. specimen, 3.5 in 155 mm. specimen.

TABLE 24
VARIATION IN FIN RAY COUNTS OF SPECIMENS OF *Acanthurus bahianus* FROM DIFFERENT LOCALITIES

LOCALITY	DORSAL SOFT RAYS				ANAL SOFT RAYS		
	23	24	25	26	21	22	23
Massachusetts	1					1	
Bermuda			2				2
Florida		2	1		1	2	
West Indies	2	19	8	1	2	21	7
Brazil		3	1			3	1

Color (in alcohol) brown, with or without narrow, faint, longitudinal lines on body; caudal fin with a definite white posterior margin which is broader in median part of fin (in maximum width about one-third the diameter of the pupil in adults, proportionally wider in young); base of caudal fin usually paler than rest of body; 9 to 11 narrow longitudinal dark lines usually visible in dorsal fin; anal fin with about four similar bands, but these usually fade in preservative; margins of dorsal and anal fins narrowly dark brown; pectoral fins light brown; membranes of pelvic fins dark brown; margin of caudal spine socket narrowly black; sheath of caudal spine dark brown; opercular membrane black.

Color in life of a 121 mm. specimen collected by the author at Bache Shoal, Florida: body light yellowish brown with faint pale greenish gray longitudinal lines (ventrally the body is dull brassy yellow and the lines are light grayish blue); throat pale grayish blue; caudal fin olive-yellow, the posterior margin bluish white; margin of dorsal and anal fins bright blue; dorsal fin with alternating lengthwise bands of dull orange and light bluish green; anal fin with alternating grayish blue and dark gray bands; pectoral rays dusky orange, membranes hyaline; pelvic rays pale blue, membranes black; a narrow violet area surrounding caudal spine; upper one-fourth of opercular membrane purple, lower three-fourths black; a purplish gray area adjacent to posterior edge of eye, this region crossed by six to seven narrow yellow lines which radiate from eye; a few small yellow spots below eye; a short blue line anterior to eye.

Longley (1941: 157) stated that this species is golden brown on the open reef and matches very well the dominant color of the algae on which it may be seen cropping all day long. Like *A. chirurgus*, it readily displays a very pale color phase.

The largest specimen seen by me measures 170 mm. in standard length. It was collected at Cuba.

I examined the type specimen of *Acanthurus tractus* Poey at the Museum of Comparative Zoology. Without doubt it is *A. bahianus*.

A. bahianus appears to be confined to the western Atlantic. It is known from Brazil to Massachusetts.

DOUBTFUL SPECIES

Acanthurus doreensis Cuvier and Valenciennes

Acanthurus doreensis Cuvier and Valenciennes (1835: 220) (Dorey Harbor, New Guinea); Bleeker (1850*a*: 5); Günther (1861: 332); Macleay (1883: 354).

Rhombotides doreensis Bleeker (1878: 51).

Hepatus doreensis Fowler (1928: 268); Jordan and Seale (1906: 351).

To my knowledge the species is known only from the type (No. A 7099) in the Paris Museum. It was described by Valenciennes as brown with the posterior part of the pectoral yellowish and the terminal border of the caudal fin with a white margin. The length was given as 8 inches. The fin ray counts D IX, 28 and A III, 20 are most distinctive, and on the basis of these Bleeker, Günther, Macleay, and Fowler all regarded the species as valid. Jordan and Seale, however, suggested that it might be the young of *Hepatus nigricans* (= *Acanthurus gahhm*) or *H. elongatus* (= *A. nigrofuscus*), and that the anal rays of the specimen were miscounted. These authors are probably in error in considering it a juvenile, for an eight-inch specimen of any known species of *Acanthurus* would be an adult or near-adult.

L. Bertin of the Paris Museum has kindly supplied the following information on the type. It is 166 mm. in standard length, has a caudal concavity of 20 mm., and 16 upper and 18 lower teeth. No black bar can be perceived on the shoulder region of the specimen. There are 28 dorsal soft rays and 20 anal soft rays. "Aucun doute à cet égard."

Of the known species of *Acanthurus*, *A. doreensis* is closest to *A. grammoptilus* Richardson. The number of teeth in the jaws, shape of the caudal fin, yellowish outer part of the pectoral fin, white posterior margin of the caudal fin, and lack of a definite mark on the shoulder region are characteristic of the latter species. The usual soft fin ray counts of D 26 and A 24 of *A. grammoptilus* do not seem to offer any possibility, however, even in the extreme range of normal variability, of ever being D 28 and A 20. In fact, the latter combination of counts can be found in no species of *Acanthurus*. It would seem, therefore, that *A. doreensis* is either an abnormal specimen of *A. grammoptilus* or is a good species. Decision on the matter should await the collection of further specimens.

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NOTES

Tagged Bigeye Tuna Recovered

A bigeye tuna *(Parathunnus sibi)* tagged by the Pacific Oceanic Fishery Investigations in the North Pacific was recently recaptured by the Japanese during their winter longline operations in waters north of the Hawaiian Islands, marking the first known bigeye tag recovery in the Pacific.

The fish was tagged on January 31, 1955, by the U. S. Fish and Wildlife Service research vessel *John R. Manning* (cruise 23), at 30° 59′N, 171°14′W, which is about 360 miles northeast of Midway Island, during an albacore survey cruise to the North Pacific. The tuna, captured by longline, measured 122.3 cm. in fork length at the time of release.

The recovery was made by a Japanese longline vessel, the *No. 5 Nikko Maru,* of the Nikko Fishing Company of Fukushima Prefecture, on November 24, 1955, at 32°41′N, 155°57′W, approximately 700 miles due north of Oahu, T. H. The straight-line distance between the points of release and recovery is 800 miles. The length of the fish at recapture was 126.8 cm., indicating a net gain in length of 4.5 cm. during the interval of 10 months. In terms of estimated weight this represents a gain of approximately 10 pounds.

This recovery was the first from a total of 82 bigeye tuna tagged and released in North Pacific waters by POFI between January, 1954, and September, 1955. The tag, in excellent condition, together with pertinent information regarding its recovery, was returned to the Pacific Oceanic Fishery Investigations laboratory through the cooperation of Mr. Shoji Ueyanagi of the Nankai Regional Fisheries Research Laboratory of Kochi, Japan. The tag used was a type "G" vinyl plastic tube tag recently developed by the California Department of Fish and Game (Wilson, R. C., 1953, Calif. Fish and Game 39(4):429-442).—*Tamio Otsu and Richard N. Uchida, Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, Honolulu.*

News Notes

Sheet 10 (the third received) of the geological map of New Caledonia and the accompanying explanatory notes have been received. For details of the map series see *Pacific Science* 8(3):369.

The address of the Office de la Recherche Scientifique et Technique Outre-Mer has been changed to 47, boulevard des Invalides, Paris-7e.

BODEN, BRIAN P., MARTIN W. JOHNSON, and EDWARD BRINTON. *Euphausiacea (Crustacea) of the North Pacific.* Scripps Institution of Oceanography, of the University of California, Bulletin. Vol. 6, No. 8, pp. 287-400, 55 figs. University of California Press, Berkeley and Los Angeles. $1.50.

Scientific expeditions, planning field work in the Melanesian, Indonesian, Philippine, Micronesian or Polynesian areas, will be interested to know that the "Gloria Maris," a 107-foot, steel-hulled, two-masted auxiliary schooner, is now available for charter in that area. The "Gloria Maris," owned by Alfred J. Ostheimer III, of Philadelphia, and chartered on a long-term basis to the Natural Science Foundation in Philadelphia, can be sub-chartered on a bareboat basis provided that Captain Ernest Chamberlain (her permanent skipper) and his experienced crew are engaged separately. Bargain charter rates are offered to scientific groups, since the Foundation's primary interest is to offset expenses rather than to make money.

The "Gloria Maris" recently completed an expedition in the Palau Islands for the purpose of collecting marine mollusks under the auspices of The Academy of Natural Sciences of Philadelphia and the Natural Science Foundation. She is temporarily based at Koror in the Palau Islands, subject to further marine mollusk collecting trips under the same auspices or such charters as can be arranged. The "Gloria Maris" can accommodate a scientific party of eight to ten individuals in comfort and has space and facilities for scientific work.

The Natural Science Foundation is also interested in locating individual scientists who might arrange to accompany future marine mollusk collecting expeditions to do field work in their own specialties in South and West Pacific areas. Obviously, there are opportunities for collecting and field studies which are entirely compatible with mollusk collecting work and the Foundation would consider providing board and lodging on the "Gloria Maris" for those able to provide their own transportation to and from the area.

Of outstanding importance to all workers concerned with decapod crustaceans is the recently received paper by Dr. L. B. Holthius, "The recent genera of the caridean and stenopodidean shrimps (class Crustacea, order Decapoda, supersection Natantia) with keys for their determination." It is published as Zoologische Verhandelingen No. 26 of the Rijksmuseum van Natuurlijke Historie te Leiden, by E. J. Brill, Leiden.